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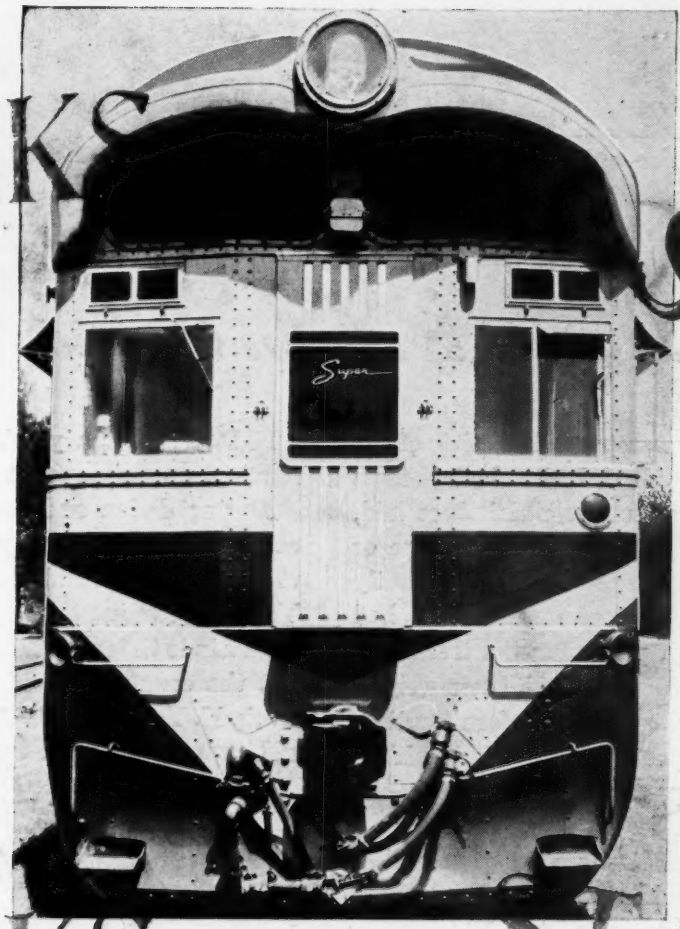

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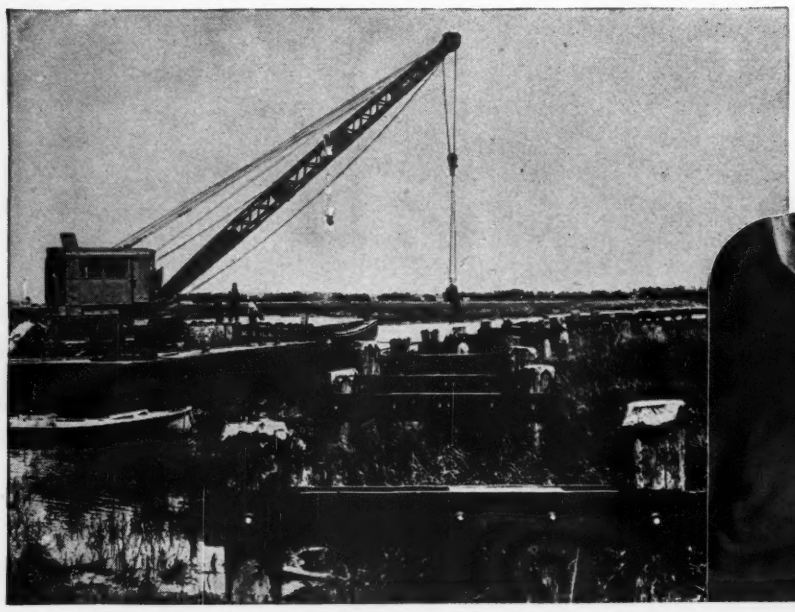
Dinosaurian Excavation

The Colloidal Engineer

MASSACHUSETTS INSTITUTE OF TECHNOLOGY



Two 10-in., one 14-in., and one 6-in. lines were laid on this trestle. Insert shows close-up of Multi-Flame Lindeweld Head in action.

Pipe Lines that couldn't fail and didn't . . . *with Lindewelding**

OVER the wastes and swamps of the Deltas of the Mississippi River, pipe lines had to be laid for a sulphur plant. Failure was unthinkable! Once laid, these lines had to stand up . . . without leakage or troubles that would jeopardize operation of a costly investment. This was the exacting demand that had to be met . . . even though piling for the trestles to support the line would sink 30 feet of its own weight.

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*Lindewelding is a new method of oxy-acetylene welding developed by the Linde engineering and research organizations. This method requires less oxygen, less acetylene and less welding rod. Welds can be completed in less time. Yet Lindewelding involves only a special flame adjustment and a "back-hand" technique, together with Oxweld No. 24 Lindeweld Process Welding Rod. When circumstances permit, the Multi-Flame Lindeweld Head can be used to increase further the speed of Lindewelding. This head costs $7.75. Lindewelding is consistently saving 15 to 40 per cent in welding time, rods and gases.

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OUR AUTHORS

DR. ERNST A. HAUSER, who wrote about *Colloids* for this number is internationally known for his work on rubber and other colloidal materials. He is a recent addition to the Institute's staff for Chemical Engineering, and will strengthen that department's program in Colloidal Chemistry. Dr. Hauser is also interested in the mechanism by which marked changes in the physical properties of materials are brought about by the relatively small proportions of dispersion agents, and also plans a comprehensive investigation of the phenomenon of thixotropy.

Dr. Hauser received his Doctorate from the University of Vienna in 1921. His enormous experience in the rubber industry, and in colloid research have made him a world authority in the field of this science. Dr. Hauser held a previous appointment in the Department of Chemical Engineering during the Summer of 1928. Before taking his appointment this year, Dr. Hauser made a round-the-world tour in the interest of his profession.

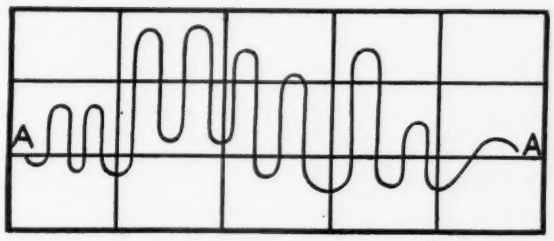
Among the honors that have been bestowed upon him, are the Medallion of the German Society of Rubber Chemists, and the Harries Medal for Colloid Chemistry.

JAMES ELIOT BOOGE, co-author of the article on *Uses of Titanium* attended both the University of Iowa and Columbia University. He received his Ph.D. from the latter in 1916. From 1917 to 1925 Mr. Booge was at the DuPont experimental station, and was in charge of pigment, paint, and miscellaneous research subjects there. From 1925 to the present time he has been Chemical Director of the Krebs Pigment and Color Corporation.

DR. J. L. GILLSON, the other co-author of *Titanium as a Pigment,* is a graduate of Northwestern University. He received an Sc.D. degree from M.I.T. in 1923. He subsequently became an instructor at Harvard and still later became an instructor at M.I.T. From 1927–1929 he was Associate Professor of Mineralogy and Petrography at the Institute. During this period he did field work for the United States Geological Survey in the mining camps of Idaho and Nevada. He joined the DuPont organization in 1929 and has since examined mineral resources in Quebec, India, Norway, and Africa.

J. J. DEL BOURGO, author of the article on the determining of *Lateral Pressures* on retaining walls, received his B.S. degree in Civil Engineering from Cornell University in 1924. From 1924 to 1926 he was with the Board of Transportation of the City of New York. In 1930 he was made Assistant Engineer of the Transit Bureau of Newark, N. J. From 1930 to the present date he has been employed as a Structural Engineer by the Rankine Engineering Corporation, of New York City, and has also acted as a Consulting Engineer. It is thought Mr. Del Bourgo's new formulae, published in this issue, will prove quite useful. He has been working on them for a number of years.

PAUL SHIRLEY JR., a second year student of Chemical Engineering (Course X) at the Institute, is the author of the article on *Dinosaurs* which appears in this issue. He is a graduate of the Philip's Andover Academy. With his father he has done a great deal of traveling and exploring in the arid regions of the Far West, and has collected an impressive collection of fossils.



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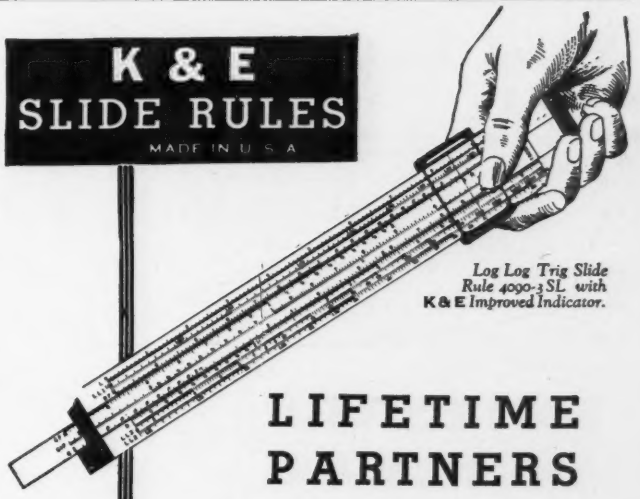

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T. E. N.'s BRAINSTORM CONTEST

THE Managing Board of T.E.N. takes pleasure in announcing the winners of its Freshman Brainstorm Contest. The basic reason for this contest was made clear in the November T.E.N., and will bear repeating at this time.

Before the Freshmen are told to forget everything they learned at high school, and before their minds are slowly but so certainly guided to think, breathe, and believe engineering by our distinguished and persistent instructing staff, T.E.N. wants to investigate their minds. The Managing Board believes that this is the first time an attempt has been made to furnish an insight into the brains of the cream of the high and prep schools from all over the world.

The contest judges endeavored to pick a device that was truly useful rather than one of a Rube Golbergian nature.

The names of the prize winners are as follows:

1st Ronald Deering (V), "A Soft Tire Warning Device"
2nd John F. Allen (VI-A), "Sound Recording on Film"
3rd Paul E. Sandorff (XVI), "Electric Clutch"
4th Lucius P. Taylor, "Self-Releasing Clutch"
5th Antonio Arias (II), "Automatic Coat Room"
6th Paul E. Sandorff (XVI), "Filtering by Osmotic Pressure"
7th R. Dixon Speas (XVI), "Hydraulic Plane Levelizer"
8th Robert Hilliard (VIII), "Calculating Machine"

Below is a description and drawing of the first prize.

SOFT TIRE WARNING DEVICE

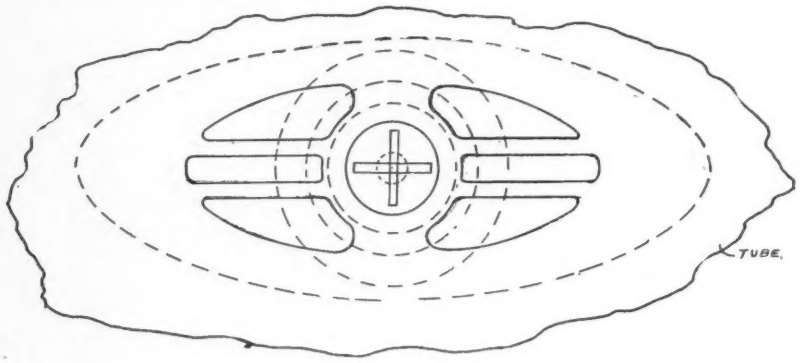
THE motorist first becomes aware of a flat tire when his car swerves, or when a tremendous torque develops in the steering wheel of the automobile. Because of the frequency of accidents resulting from these factors, the need of a premonitory device exists.

Any such device must take advantage of the varying changes of the tire as it deflates. The conditions of a deflating tire are: decreasing air pressure, and depressing of that part of the shoe in contact with the road. It is this depressing of the shoe which operates the following gadget.

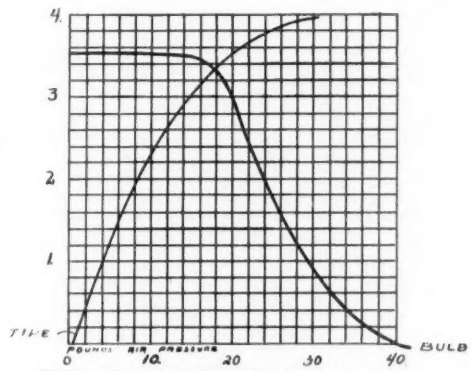
Molded upon the inside circumference of, and within the tube, is an acorn-shaped rubber bulb set into a soft cushion or shoulder, also of rubber. The top of the bulb (A) comes close to the opposite part (B) of the tube. At the bottom of the bulb, there is an outlet into the atmosphere, and a whistle or other sound device, is inserted in this outlet. The depressing of the tread of the shoe at point B, compresses the air in the bulb. The compressed air, in passing through the outlet, produces sound.

The construction is such that the bulb retains its form against an inward pressure of approximately twelve pounds. At the normal pressure of a tire (thirty-five pounds) the bulb may collapse, but since a tire does not begin to flatten until the pressure has dropped to about twelve pounds, the device would not function anyway. The rate of flow of the leaking air is less at the lower pressures, however, and the warning sound will be heard before the tire is flat.

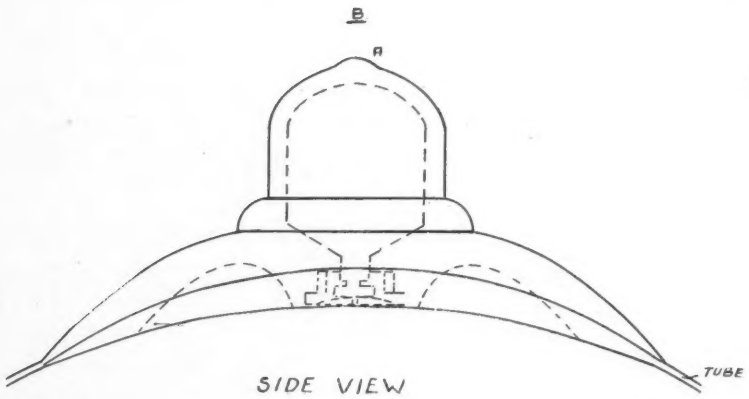
If tires equipped with this device puncture, each revolution of the wheel will produce a sharp sound. The motorist will have time to stop with full control of his car. In a large majority of such cases, he (or she) would have time to proceed to a repair shop before the tire becomes completely flat.



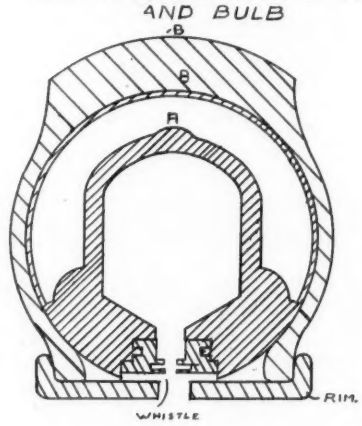
BOTTOM VIEW



RELATIVE BEHAVIOR OF TIRE AND BULB



SIDE VIEW



SECTIONAL VIEW.

THE TECH ENGINEERING NEWS

DECEMBER, 1935
VOLUME XVI
NUMBER 6

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Published monthly throughout the school year, at Walker Memorial, Cambridge A, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergraduates. Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879. Acceptance for mailing at special rates of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920. Copyright 1935 by The Tech Engineering News. Subscription per year $1.50. Foreign $1.75. Single copies 25 cents.

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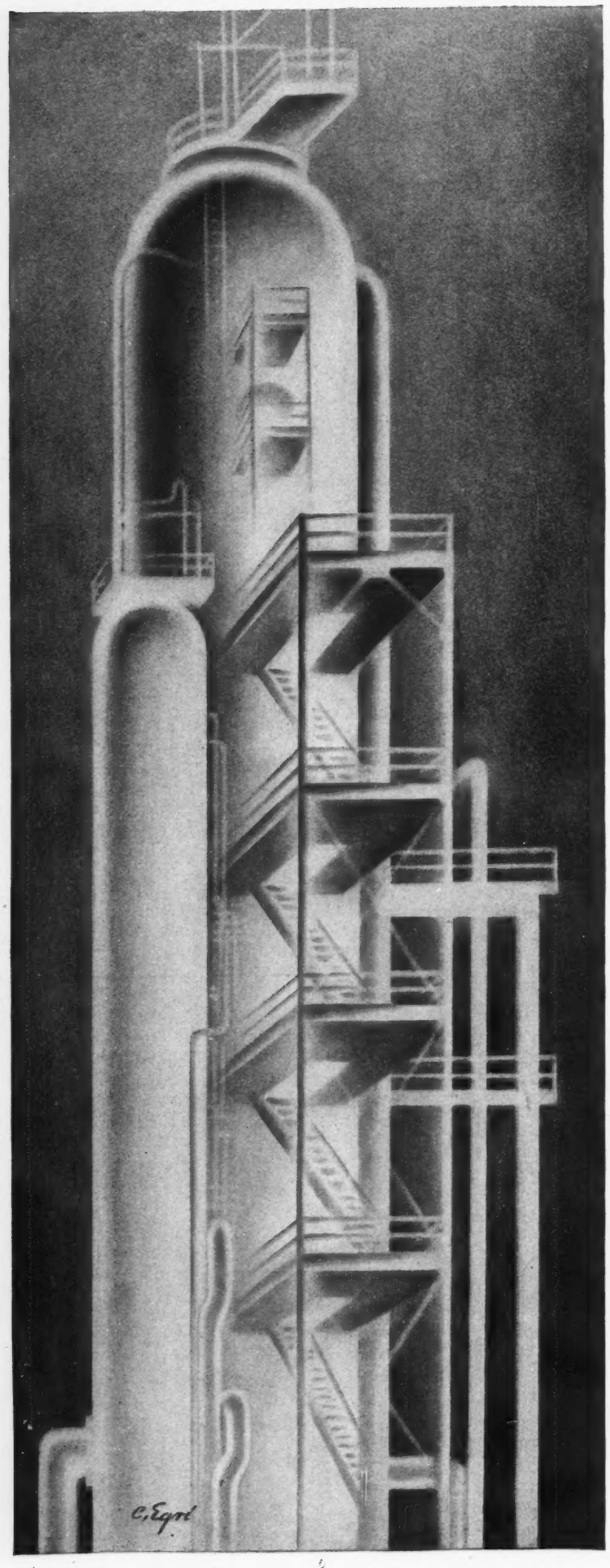


TALL TUBES

THE COLLOIDAL ENGINEER

By E. A. Hauser, Ph. D.
Massachusetts Institute of Technology

"IT'S colloidalized", "It's unsurpassed efficiency is based on its colloidal properties", "Look for better dispersion" are slogans which have comparatively recently been introduced into the advertising campaign of several industries. It is the word "colloidal" which in our days of scientific and technical development seems to have the greatest force behind it. In other words, everything pertaining to "colloids" has suddenly become very modern.

We who have been more or less specializing in this new branch of chemical and physical science know very well its importance in the future development of science and industry. On the other hand, just as often as you read such slogans, you will find people questioning you as to what all this concerns.

Before discussing the actual subject of this sketch, it therefore seems advisable to lay before the readers some of the fundamentals of colloidal science.

In 1861 the famous English chemist, *Thomas Graham*, published a series of papers regarding the behavior of different substances when placed in a parchment sac, or the like, which was surrounded by water. He found that certain substances, mainly crystallizable matter, would pass through the membrane into the surrounding liquid, whereas others, as for example, glue, were retained in the parchment sac. This process he termed "dialysis" (the Greek expression for "brought into solution through"), meaning that the substance was dissolved by the surrounding water and passed into it through the membrane. Substances exhibiting this effect were termed "crystalloids" by Graham, whereas all substances which were retained were termed "colloids", the name being derived from the Greek word for glue — "Kolla".

Although Graham's differentiation still can be recognized as an outstanding characteristic of colloidal matter, it has since been proved that the inability to diffuse or dialyse through a definite membrane is only one of the properties peculiar to colloids, and that they are in general characterized by a great number of other exceptional features.

The most important advance in our knowledge since Graham's day is the discovery that the term "colloid" does not refer to any specific group of substances, but to a special intermediate state of matter. Theoretically, every substance or chemical compound can be brought into colloidal condition. It has been proved that any substance which exists in a state of fineness where the diameters of particles range between 0.0005 mm. to 0.000001 mm. exhibits properties which are not common to the substance if its particles are either larger or smaller than this range — in other words, in a coarse degree of dispersion, or in true solution, (so-called molecular dispersion.) This intermediate state represents the "colloidal state of matter", and the dimensions referred to are termed "colloidal dimensions".

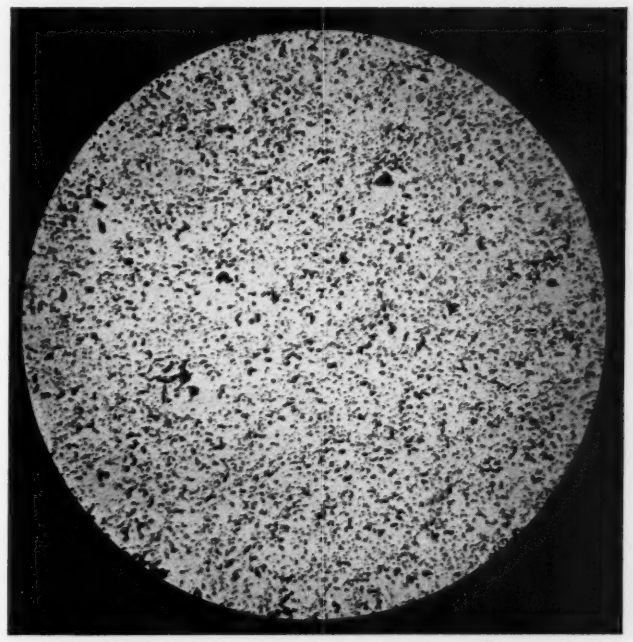
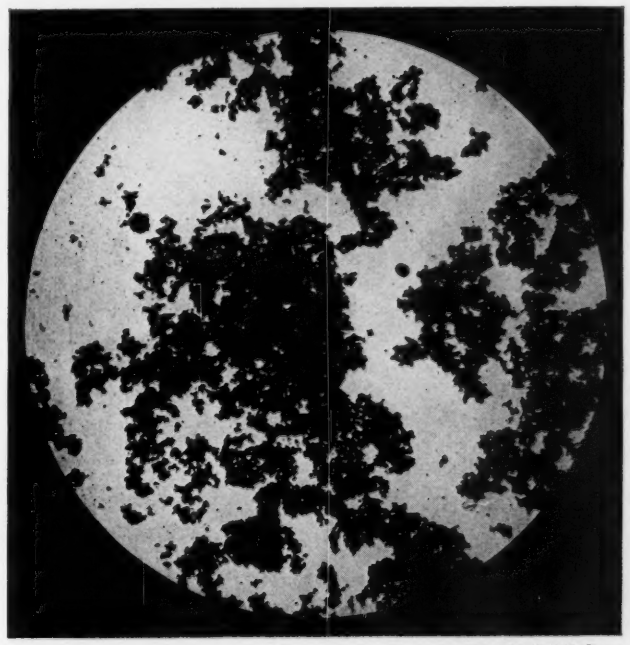


Fig. 1. Zinc oxide-water dispersion with a dispersion agent added.



—*R. T. Vanderbilt Co.*

Fig. 2. Zinc oxide-water dispersion.

Besides showing the inability to dialyse, matter in the colloidal state will exhibit, as mentioned, a variety of pronounced effects, which are very dependant to particle size; for example, a marked degree of change in viscosity, changes in surface tension, covering power in the case of pigments, color strength or coefficient of absorption (Fig. 4), increasing turbidity, vastly increased adhesive properties, and marked characteristics of absorption.

The production of colloids can be achieved from two directions: by disintegrating a substance from its coarse state down to the point where its comminution reaches colloidal dimensions, or, starting from molecular dispersed systems, condensing the molecules until they build up to

dimensions entering the colloidal field from the lower end (Fig. 5).

Nature has provided us with substances such as rubber, gelatin, and cellulose, which, if brought in contact with appropriate solvents, exhibit colloidal properties without any mechanical or chemical treatment, due to the fact that the sizes of the molecules, or molecular aggregates, are already within the colloidal range.

Looking at the picture from a somewhat different angle, one can also express the properties of the colloidal state of matter in terms of surfaces actually exposed to the environment; in other words, the colloidal state of matter seems to be characterized by the development of a large specific surface. For example, if we take a centimeter cube, we have a specific surface of 6.00. If we chip off slices of that cube of a thickness of .00001 mm., we will obtain a total surface of 200 sq. meters (laminar difformation). If we divide each of those chips into bars of the same thickness mentioned above, the surface over all would increase to 400 sq. meters (fibrillar difformation), and if we finally cut up each bar into cubes having edges of the same 0.00001 mm. length, the total surface will have increased to 600 sq. meters (corpuscular difformation). These simple calculations demonstrate the vast increase in obtainable surface area when starting from a substance present in the coarse state (Fig. 6).

Expressed in terms of surface per unit volume, the colloidal state ranges from perhaps 10 to 5000 square meters per cubic centimeter of material. A common example of laminar difformation is the plate-like particles of plastic clays. Silk illustrates the fibrous structure described as fibrillar difformation, and colloidal sulphur is typical of corpuscular difformation.

Now, starting from "molecular dispersions", that is, true solutions, we may assume that the surface of the imaginary particles present is infinite, and we can create that specific surface needed to obtain colloidal properties by linking imaginary particles together until their united surface reaches the limits of colloidal surface dimensions. This question of surface is so dominant in the behavior and properties of colloids, that colloidal science is fairly defined as *the physics and chemistry of surfaces and of surface reactions.*

The colloidal chemist and physicist at the very beginning of their work were faced with the fact that there were already in existence a number of industries which were utilizing and manipulating many of the substances which the research man was just starting to investigate. In the case of the organic chemical industry, which offers a striking contrast, the industry can well be called the "pupil" of the research man and inventor. In the case of the colloidal chemical industry, relations are somewhat different. In the very beginning of systematic colloidal research, undoubtedly the research man had to learn much from industry, and in many cases he still can learn today. But his never-ceasing efforts have finally put him in a position where he can, based on his fundamental knowledge of what is going on in this "world of neglected dimensions", repay his teacher multifold, and make industry in turn a "student" of the knowledge he has acquired in the laboratory.

Increasing knowledge of the behavior of colloids and of their specific properties is enabling us to introduce the findings of colloidal research advantageously into an increasing number of industries which previously had never even thought of colloidal reactions. We are increasingly successful in improving manufacturing processes in typical colloidal industries due to a greater knowledge of the reactions actually governing the processes, and, thanks to the information obtained by elaborate research work, we can straighten out difficulties which had been earlier regarded almost as acts of God. This refers not only to industries which have actually had no direct connection with colloidal science so far, but even to those that have been dealing with typical colloidal matter for years and years, and especially to the problems of viscous and plastic flow.

One might say that the application of colloidal science is changing the colloidal industries from a typical "foreman's job" into the type which demands and justifies intelligent control and development by chemists and chemical engineers. The colossal developments of the rubber industry and of the industries using cellulose as raw material, the improvements in the manufacture of gelatin and glue, and last, but not least, the amazing advances in the manufacture of photographic films and papers are illustrations of this progress. It is, therefore, not astonishing that the general interest in colloidal chemistry and physics is rising.

When, just for the sake of example, we realize that rubber, paper, ceramics, cement, paint, varnish, and the various plastics are depending more and more on the use of additional compounding ingredients of a greater degree of fineness, one readily appreciates that the possibility of obtaining these additional ingredients in colloidal sub-division is a predominant problem. The difficulty of producing such fine comminutions mechanically, starting from matter in the coarse state, has, up to recently, necessitated starting wherever possible from solutions or from melts to obtain the desired particle sizes by condensation. In many cases this is impossible or costly. Quite recently it has been found that certain substances, generally termed "dispersing agents", (Fig. 1 and 2) will assist in producing colloidally comminuted particles by mechanical means, and substances, generally called protective colloids, have been found which will maintain such colloidally dispersed matter in that condition.

It seems practically certain that the coming years will show a remarkable increase in the application of colloidal research. It is a recognized fact today that a successful chemical industry must have chemists and chemical engineers for research and development on new processes and improvements as well as for the control of present operations. In my opinion, a basic training in the chemistry and physics of colloids is not only of utmost significance to such men in the typical colloid industries but should also prove of fundamental value in other industries where the colloidal applications are not as yet obvious.

The increasing number of engineering problems associated with colloidal phenomena makes it particularly imperative that the chemical engineer of the future be familiar with colloidal science. I refer in this connection to problems like dry and wet grinding operations, processes of absorption and catalysis where results depend to a great extent on surface reactions, drying of colloidal substances under conditions appropriate to that specific state of matter, filtration processes in connection with precipitates of colloidal dimensions,

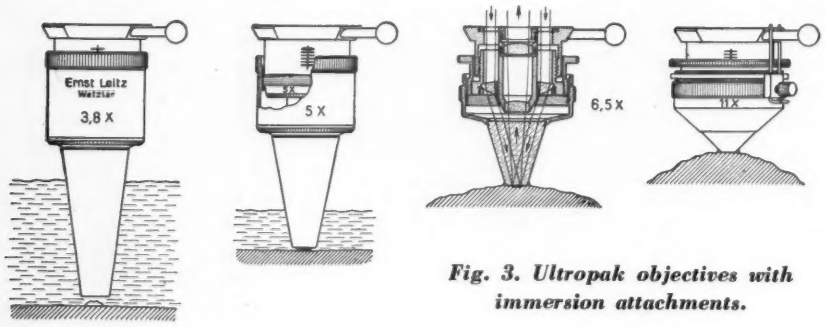


Fig. 3. Ultropak objectives with immersion attachments.

the design of devices in connection with coagulating reactions in the various flotation methods, the adaption of certain steps in the manufacture of cements, and in the field of ceramics the use of ingredients in the colloidal state. Finally engineering problems occur almost everywhere where viscosity and plasticity are important properties.

In closing let me make a few remarks regarding the general training required for a competent "colloidal engineer". Besides a background of fundamental science and of professional training in all lines of chemical engineering and a basic knowledge of colloidal chemistry and physics, he should be familiar in a general way with the applications which colloidal

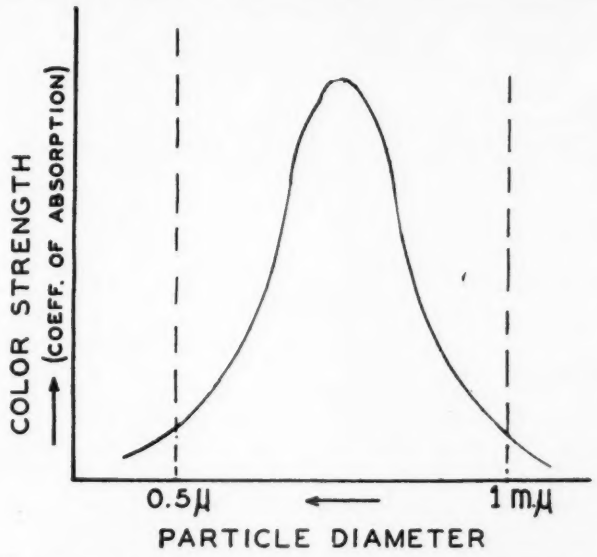


Fig. 4. Curve showing the marked changes in regard to color strengths or coefficient of light absorption when the individual particles obtain colloidal dimensions.

chemistry has so far found in industrial enterprises. It seems preferable to have a general background covering as many fields as possible rather than to specialize on one individual field. Besides such training, it seems necessary to familiarize oneself with at least some of the outstanding modern methods of colloidal research work, partly for the purpose of using them oneself, but principally so that their advantageous use may be encouraged and that the findings may be properly interpreted. Good examples of such methods and equipment are research on X-ray diffraction and the use of microscopes in studying colloid phenomena.

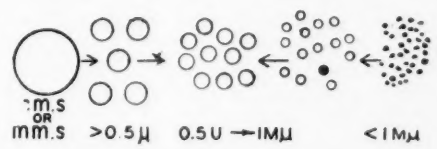


Fig. 5. Schematic explanation of existing matter from its coarse state down to molecular dimensions, the colloidal range being in the middle.

The optical industry has devoted much of its time in recent years to the development of instruments especially adapted to colloidal science — instruments which not only assist in the observation of reactions, but which have been so devised that drawbacks of former instruments have been carefully avoided. It ought to suffice here to refer to two new types of optical instruments which have already proved their value in such problems.

Fig. 7. The "ultropak" microscope set up for dark field illumination.

The possibility of observing colloidal dispersions by vertical illumination and at the same time avoiding any blurring effects through the turbidity of the solution under investigation has been made possible by the Ultropak type instrument (Fig. 7) especially with the aid of the immersion attachments (Fig. 3) so that we can study dispersions in considerable depth. This avoids danger of obtaining results not comparable to true conditions because of excessive surface reaction caused by the low depths of microscopic preparations used by the older methods.

The use of the phenomenon of fluorescence in microscopic observation is enabling us more and more to study visibly a great number of reactions on surfaces, etc., which have so

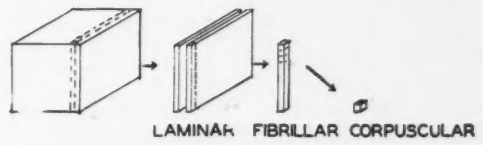
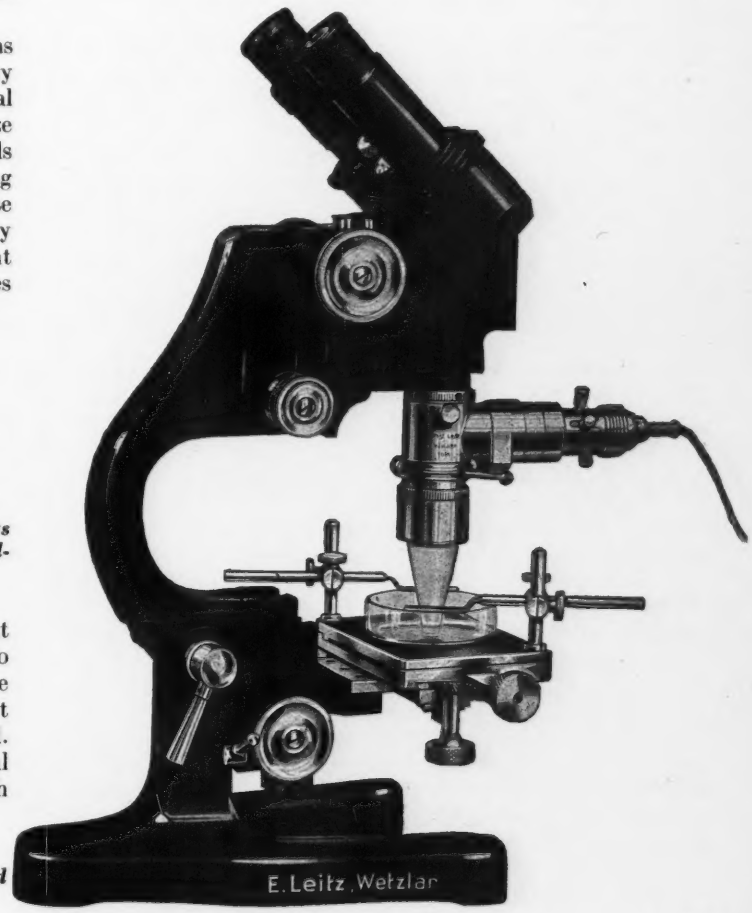


Fig. 6. Schematic drawing showing the three ways of disintegration of a cube into systems of laminar, fibrillar and corpuscular dispersion.

far escaped direct observation Such instruments allow us to get a decidedly deeper insight into methods of mechanical dispersion and of condensation than ever before, and a closer study and knowledge of these reactions will enable the colloidal engineer to devise adequate installations on a larger scale.

Summarizing, one may state that colloidal science—the chemistry and physics of the colloidal state of matter, or the science of surfaces and of surface reactions — must be con-

(*Continued on page 132*)



Discovering Remains of
DINOSAURS
— Engineering Excavations

By PAUL SHIRLEY, JR., '38
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THE most monstrous, ferocious, and unbelievable of all living creatures were the dinosaurs. In all times, man has been interested in the unusual and especially the unbelievable; if truth and fact are connected with it, all the better; hence this continuing interest in dinosaurs. His knowledge of them is based upon inescapeable proof in the form of fossils. About these factual bones rises a story of a world fictional when related to modern civilization.

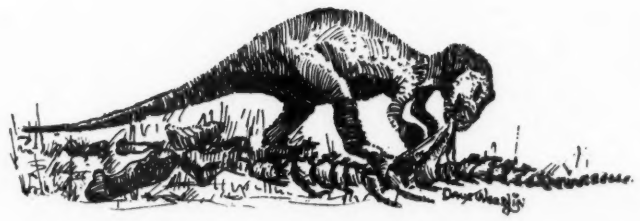
The story of the origin and development of the dinosaurs is a part of the fascinating tale of the evolution of life. Invariably, the question arises of why these animals, strong, powerful, and invincible as they were, should die out and become extinct. It is a question better answered after their story has been told, and, before telling the story, it is better to understand a few of the means by which scientists have been able to tell it and to know also some of the preceding events.

For convenience, geologists have divided the life of the earth into five eras: Cenozoic, meaning "recent life", which includes modern times; Mesozoic, "middle life"; Paleozoic, "old life"; Proterozoic, "premature life"; Archeozoic, "ancient life". These main headings have been subdivided into periods and epochs. The age of the earth has been placed at over two billion years, which gives some idea of the time interval for these periods. In determining this figure, the breaking-down process of radio-active elements, uranium and thorium, has been used.

Our knowledge of past life has come from studying the remains of organisms or fossils preserved in stratified rock that has been formed by layers of mud, sand, and limestone. These strata, containing fossils, are the graveyards of lost species, which connect the past with the present. Fossils vary from the imprint of a leaf to the preservation of the entire skeleton, and even the soft parts such as the stomach. Most fossils are only external shells or internal skeletons or both. Often mineral matter has filled or completely replaced substance. This change does not generally alter the appearance or shape of the remains.

Traces of life are but few in rocks of the Archeozoic period. Beds of graphite and of limestone offer indirect proof that life existed. The age of invertebrates, animals without a backbone, did not start until well into the Archeozoic era and continued through the Proterozoic. The oldest known fossils appear in Proterozoic rocks. They are filaments of tiny plants related to some of the algae that grow today in our shallow seas. These can be seen only when the rocks containing them are cut very thin and placed under a microscope.

The lung fishes form an important step in vertebrate development, a step which ultimately leads to the ability of animals to live on land. They had in addition to gills one or two lungs for breathing air. The Barramunda, a survival of the Paleozoic era, is an extraordinary lung fish of Australia and might be called a "living fossil". Remains of this type show that in the early geologic ages members of its family were distributed nearly all over the world. The present day representative is covered with big scales, and looks more like a huge, dark-colored salamander than a fish. When its ponds and streams become, in dry spells, too stale to live in, the fish comes to the surface or crawls out upon the muddy shore. Its eggs are in a gelatinous envelope like those of amphibians.



Amphibians are the connecting link between fishes and reptiles. They arose during the Devonian period and soon became dominant. Varying greatly in size and shape, some attained the length of twelve feet.

A race of now extinct amphibians, many of giant size, found in Carboniferous and Triassic strata, which are called the Labyrinthodonts, like modern amphibia, breathed through gills when young and with lungs when adult. The Salamander of today belongs to this type. Since the young breathe by means of gills for at least a short time, amphibians were dependent upon water. The hindrance of always returning to water to lay eggs was overcome in the development of the reptiles, for, with them, the gill breathing stage was passed within the egg.

With the rise of amphibians, we find animal life slowly leaving the water, and with the advent of reptiles it was firmly established upon land. They invented the world's first true egg-shells and thus became independent of the water. The descriptive word *reptile* means an animal that moves on its belly or crawls on short legs. But not all reptiles were creeping or crawling animals. Some of them developed into swift lizards, certain of the huge dinosaurs, and the winged dragons. During the Mesozoic era, reptiles were dominant on land, in the sea, and in the air. Several types of reptiles went back to the sea, and we find that some of them attained the length of thirty to forty feet, showing that there must have been an abundance of food and that they must have possessed great agility in getting it.

Perhaps the most interesting of these creatures, aside from the dinosaurs, were the winged dragons or Pterodactyls. They had long, slender jaws with pointed teeth. The legs, like those of bats, were small and weak and the tail was very short in some species and very long in others. That these dragons had the power of true flight is shown by the hollow pneumatic bones like those of birds and by the keel of the breast bone for attachment of the great muscles of flight. Birds and bats have the keeled breast bone, but flying squirrels, that merely glide, lack it.

The most famous dinosaurs are the following: the amphibious dinosaur, Brontosaurus; the carnivorous dinosaur, Tyranosaurus; the armored dinosaur, Stegosaurus; the horned dinosaur, Tricerotops; the duck-billed dinosaur, Trachodon.

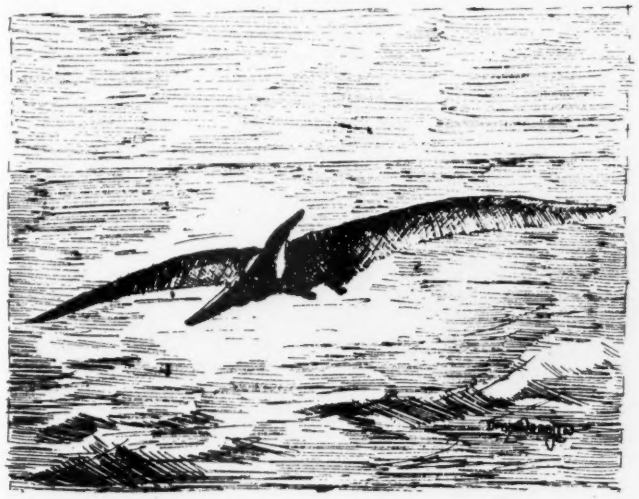
The Brontosaurus and its relative Diplodocus were the Giant Reptiles, and were by far the largest of all four-footed animals, exceeded in bulk only by the modern whales. In contrast to the two-footed carnivorous dinosaurs, they were four-footed, with small heads, blunt teeth, long giraffe-like necks, elephantine bodys and limbs, and long massive tails.

The Brontosaurus had five short toes on each foot like the elephant, and these toes were probably buried, in life, in a large soft pad. We believe that the Brontosaurus spent most of its life in shallow water, partly immersed, wading about on the bottom. In the swamps it could find abundant vegetation and be fairly safe from the active carnivorous dinosaurs which were its principle enemies. The water would buoy up the massive body and prevent the full weight from pressing too heavily on the imperfect joints of the limb and foot bones, which were covered during life with thick cartilage, like the joints of whales and other aquatic animals. The brain of these beasts was a bar of nerve-stuff 10 inches long and 2 inches thick, small even for a reptile. The spinal cord was larger than the brain, especially in the sacrum, and one might truly say the Brontosaurus had more brain in his hips than in his head. Instinct was a chief controlling factor of all he did.

The carnivorous dinosaurs were half lizard, half bird in proportions, having the head, short neck, small fore-limbs, and long tail of the lizard, and the short, compact body, long powerful hind-limbs, and three-toed feet of the bird. Largest of them all was the gigantic Tyrannosaurus, which equalled the elephant in bulk. He walked upon the hind legs. His fore-limbs were equipped with long sharp claws and were used solely in catching and tearing prey. The fossil foot-prints of these three-toed dinosaurs were at first thought to be bird tracks.

The armored dinosaurs had massive bony plates, crests, or spines covering the body and tail. They were almost completely four-footed and developed their armor as a protection from the attacks of the carnivorous dinosaurs. Stegosaurus had a double row of bony plates along his back, projecting upward and outward alternately to one side and the other. Of these plates the largest was just back of the pelvis and was two and a half feet long, over two feet high, and thinned out from a base four inches thick. The tail had spikes two feet long and five or six inches thick at the base. Its head was unbelievably small for so large an animal, and the stiff, thick tail projected backwards but was not long enough to reach the ground.

The most striking feature of the Horned Dinosaurs is the gigantic skull, armed with a pair of horns over the eyes, a horn on the nose, and a bony ruff at the rear extending to the back and sides. In some species, the skull with its bony frill is seven or eight feet long and about three feet wide. The best known of the horned dinosaurs, Tricerotops, has long and stout paired horns and a short or almost absent front horn. The teeth are broadened out into wide grinding surfaces. Somewhat suggestive of modern rhinoceroses, the animal was four footed, with massive short limbs and rounded elephantine feet tipped with hoofs, three in the hind feet and four in the front, a short thick tail, a broad-barrelled body and a neck hidden completely by the overhanging bony frill of the skull.



Perhaps more is known about the duck-billed dinosaurs, Trachodonts, than about any other genus of dinosaur. Their skeletons are not only found more frequently articulated, but parts of the skin are often preserved with them. The American Museum found one with so much skin preserved that he might be called a mummy. The mouth of Trachodon was expanded to form a broad duck-billed snout, with more than 2000 teeth — 10 to 14 rows in each jaw.

How do we know all this? The stratum in which the bones are found also yields plants and animals, which tell much about the environment at the time the formation was laid down. We can tell whether the particular stratum was once a lake bottom, the shore of a lake, a river delta, or dry land. By studying the fossil bones themselves and comparing them to those of modern animals, we can infer accurately the majority of the animal's habits.

The chief dinosaur beds in this country stretch from Canada to Texas along the flanks of the Rocky Mountains. Dinosaurs probably ranged all over America, but conditions in the middle west and east have not been favorable, except in a few localities, for preserving their remains, and these few localities are for the most part covered by vegetation which makes exploring difficult. Many dinosaur tracks and a few bones have been found in New England. In the West the dinosaur formations girdle the Rockies and outlying mountain chains for two thousand miles and are extensively exposed by erosion. Much of the fossil-bearing stratum is in desert too arid and inaccessible for exploration, but airplanes and cars are slowly making it possible to work in these regions, and new locations are being found every year. Many dinosaur localities are well known, explored, and worked, but by no means exhausted. Erosion is constantly bringing new specimens to the surface.

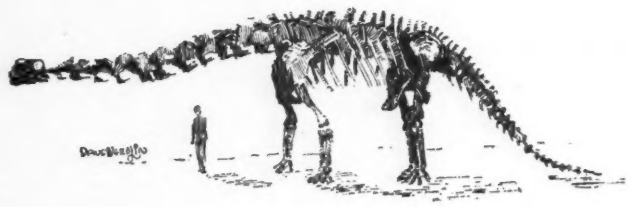
Hunting fossils is not as difficult as some people imagine, but it is an art requiring great skill for the successful gathering of good specimens. The fossil hunter selects some promising exposures of the fossil-bearing formation, and sets out to prospect on foot. He makes his way slowly, his eyes alert for fossil bones or teeth. Finding something, he stops and investigates. Sometimes he is rewarded by an unusual specimen, but more often he finds the material of no importance. Fossil hunting is a fascinating and exciting business.

Some fossils are found entirely weathered out from the matrix or surrounding earth. They are usually strong and durable and can be collected with very little work, but such specimens are generally only fragmentary bones and teeth or rarely a small skull and jaw. As a rule, most nearly perfect skeletons are found completely buried or with only a small

part exposed. Plowing a field, digging a well, or just chance often leads to finding a completely buried skeleton. The majority of whole skeletons have been found buried with a few bones weathering out to show where they are. Such specimens are often very brittle and require great care in excavating. Sometimes they are so powdery that one's breath can destroy them.

When a skeleton worth saving has been found, the work of excavating, preserving, and removing to the museum starts. It is this important part of fossil collecting that demands ingenuity, for nearly every skeleton offers some new problem in preserving and removing without destroying part or all of it. But there are a few general rules of attack.

When fossil collecting first started, fossils were gathered bone by bone and brought back in a jumble. To mount them, one had to be not only a paleontologist but also a puzzle expert. In many cases joining these pieces together was a hopeless task. A much better general method has been devised, and, by it, even the more delicate fossils can be collected without injury. Although this method requires much more time and labor, it is well worth while in the end. The main steps are as follows. First we scrape away the earth above the specimen to within a few inches of the bones; then we work it away carefully until the fossil is exposed on top. Excavating at a safe distance to prevent jarring, we leave the fossil standing on a pedestal of matrix. Now we

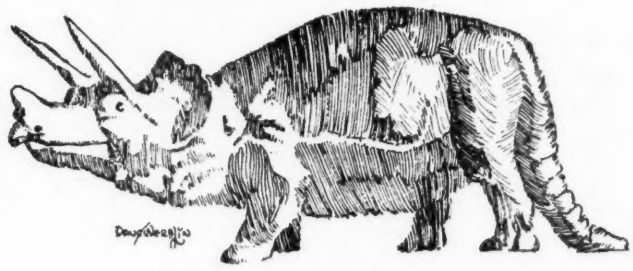


remove as much of the excess matrix as possible and cover the whole specimen with shellac or other suitable substance which will harden and protect it. Too much of the matrix must not be removed, or the specimen will be weakened. When the shellac is dry, we cover the top and sides of the pedestal with burlap and plaster of paris, and strengthen the specimen still further with wood or steel bars, if necessary. The whole bundle is then turned over and the process is repeated for the bottom. When all is done, the specimen is completely encased and protected by a hard plaster cast and is ready for transportation.

In preparing a fossil for display, still more work, time, and equipment are necessary than in collecting. The plaster cast is first removed, and then the bones are cleared from the matrix one by one and treated to make them strong enough to handle. Even our best method of collecting often leaves us with a puzzle when we are fitting the pieces together. Of course, when we find fossils completely or partly articulated, that is, with the bones in their natural position, the job of mounting is simplified.

In the collecting of many skeletons and bones of these extinct animals, unusual and interesting things are found.

Indications of pathological conditions among the bones of dinosaurs are relatively rare. For the most part they consist of fractures, abscesses, arthritides, and tumors. The Field Museum displays a "thunder lizard's" fractured rib, associated with an unhealed fracture of an adjoining rib. The injury could only have come from a blow by another dinosaur, or by a falling rock or tree. Fractured limb bones are rare among the dinosuars, probably because of their great size. An upper arm bone of a horned dinosaur found by Barnum Brown in Canada had suffered an oblique fracture which became badly infected. A pus sinus formed and the bone did not heal — proving the presence of infective germs.

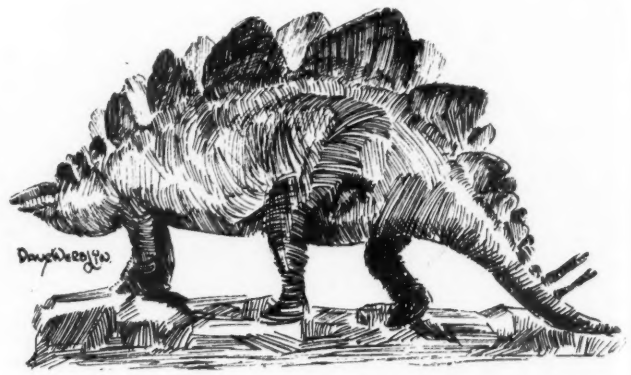


Several fossils have been found with unborn young. From Holzmaden, Germany, come many perfect skeletons of a highly characteristic Jurassic group, the *Ichthyosauria*. They were marine reptiles with a smooth skin and limbs converted into swimming paddles. One specimen of these animals now in the Stuttgart Museum contains embryos of three young; another contains a foetal skeleton twenty inches in length. In South Dakota has been found a fossil mammal accompanied by unborn young. The specimen comprises the skeleton of an adult Oreodont or ruminating hog with the skulls and small portions of two unborn young.

Finding, collecting, and studying the bones of dinosaurs have shown that these monstrous creatures existed. They were strong and invincible; it remains now to try to point out why they should have become extinct.

Explanations can be offered, but none of them satisfactorily answer the question of why the various dinosaurs should die out. There is at present no satisfactory answer. One might point to changing climatic conditions as the cause for their disappearance, but such changes are always slow and the dinosaurs were by no means incapable of travel. Many of them could and did travel great distances. Various species were accustomed to sea, desert, dry land, or swamp life. One and all of these conditions have always existed. Disease might have wiped out a small group of dinosaurs but never the many forms living in nearly all parts of the world. It is believed that the small and more intelligent mammals fed on dinosaur eggs, but this could never have brought the dinosaurs to extinction. Animals preyed upon by egg-eaters protect themselves by producing a larger number of eggs.

Throughout their supremacy, the dinosaurs had every chance to survive. They developed into many forms, most of them curious and bizarre, all to become extinct. It was the warm-blooded mammal, insignificant at the time the reptiles reigned, that was in its turn to become supreme.



Rational Formulae for

LATERAL PRESSURES

on Retaining Walls

BY J. J. DEL BOURGO
Consulting Civil Engineer

THE general problem dealt with in this paper is the determination of the lateral thrust on the back of a primary retaining wall supporting a level fill on which is superimposed a second retaining wall, the pressure on the base of which is a uniformly varying pressure. A special case of this problem is one in which the superimposed load is a uniformly distributed load, as in the case of a railroad or a continuous footing near and parallel to the primary wall.

Methods for the determination of the lateral thrust for this special case are given in most handbooks. One method is based on the assumption that an equivalent earth surcharge may be substituted for the railroad or foundation load and the thrust determined by Rankine's theory. Another method assumes a uniformly distributed load spreading through the earth at an angle of about 30° and exerting a uniformly distributed horizontal pressure on the vertical retaining wall from the point where the spread line intersects the wall to the bottom of the wall, the intensity of this horizontal pressure being a fraction of the intensity of the vertical pressure, the fractional constant depending upon the material and being determined empirically.

These and other methods known to the writer have been found to give lateral pressures too high for economical design, and the purpose of this paper is to develop rational formulæ which will justify the use of lower constants. The formulæ express the intensity of the lateral thrust as a function of the intensity of the superimposed load, the distance of the load from the wall, and yield pressure diagrams approximating the actual distribution of thrust.

All discussions of earth pressures must necessarily be based on certain reasonable or experimentally determined assumptions, and in this paper the following generally accepted assumptions are made. It will be observed that most of these assumptions are the same as those made by Rankine in his development of the earth pressure theory.[1]

(1) The soil is elastic, and the bearing stress has not been exceeded.

(2) The fill is a homogeneous mass of granular material possessing friction but no cohesion.

(3) The thrust due to the fill can be calculated by Rankine's or Coulomb's theory separately from the thrust due to superimposed loads.

(4) All forces under discussion are in equilibrium.

(5) The angle of spread (θ) decreases as the angle of internal friction (ϕ) increases.

(6) The angle of internal friction (ϕ) is equal to the angle of repose.

[1] W. J. M. Rankine, "On the Stability of Loose Earth," *Philosophical Transactions*, 1856.

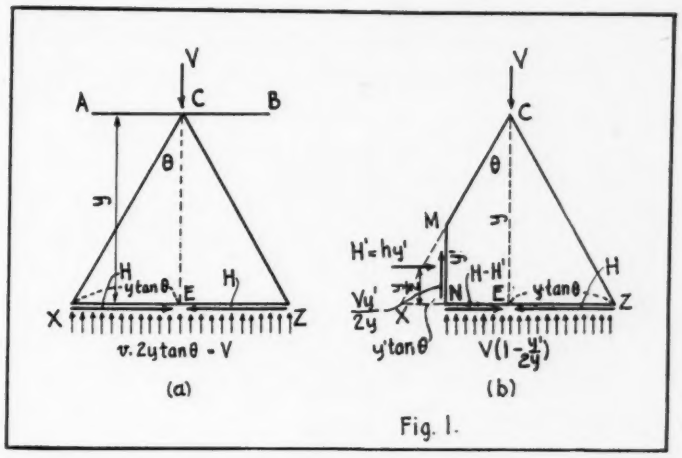


Fig. 1.

(7) The plane of spread is parallel to the plane of rupture, which approximately bisects the complement of the angle of repose.

(8) Compression of the soil under loading is neglected.

As is usual in discussions of continuous walls, all forces mentioned or shown in diagrams, unless otherwise indicated, are forces against a section of wall 1 ft. long.

Rankine's formula for the total thrust against the back of a vertical retaining wall retaining a level fill is

$$P_E = \frac{1 - \sin\phi}{1 + \sin\phi} \cdot \frac{wh^2}{2}$$

in which

P_E is the total lateral thrust;

w is the weight per cu. ft. of the retained material;

h is the height from the foot of the wall to the surface of the fill;

ϕ is the angle of internal friction.

The direction of the thrust is parallel to the surface, or horizontal, and its point of application is $\frac{h}{3}$ from the bottom of the wall. The pressure diagram is a triangle, the intensity at any point varying uniformly with the depth and being equal to

$$p_E = \frac{1 - \sin\phi}{1 + \sin\phi} wh. \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In accordance with assumption (3), in developing an expression for the lateral pressure due to the surcharge only, the pressure due to the weight of the soil need not be considered. The soil will be considered only as a medium through which the stresses can be transmitted.

Fig. 1 (a) represents a load V acting downward on an earth surface AB. In accordance with assumptions (5), (6), and (7), the load V spreads through the earth at an angle which depends upon the physical properties of the soil but which is usually ,more or less, 30°. At a plane XZ at a depth y from the surface, the load V is held in equilibrium by a uniformly distributed upward reaction against the plane XZ equal to

$$V = v \cdot 2y \tan\theta$$

in which v is the upward pressure per foot. The H's are equal horizontal forces acting along the plane XZ.

In Fig. 1 (b) is shown the wedge CXZ intersected by a vertical wall MN which cuts off from the base a portion XN. Therefore, that portion of the force H which would be distributed along XN if the wall MN were not there is resisted by the wall and distributed along the surface MN. If H′ is the total reaction against this surface,

$$H' = \frac{XN}{XE} \cdot H = \frac{y' \tan\theta}{y \tan\theta} H = \frac{y'}{y} H$$

H′ is proportional to y′; therefore, its intensity h is uniform and its point of application is $\frac{1}{2}$y above N. By a similar

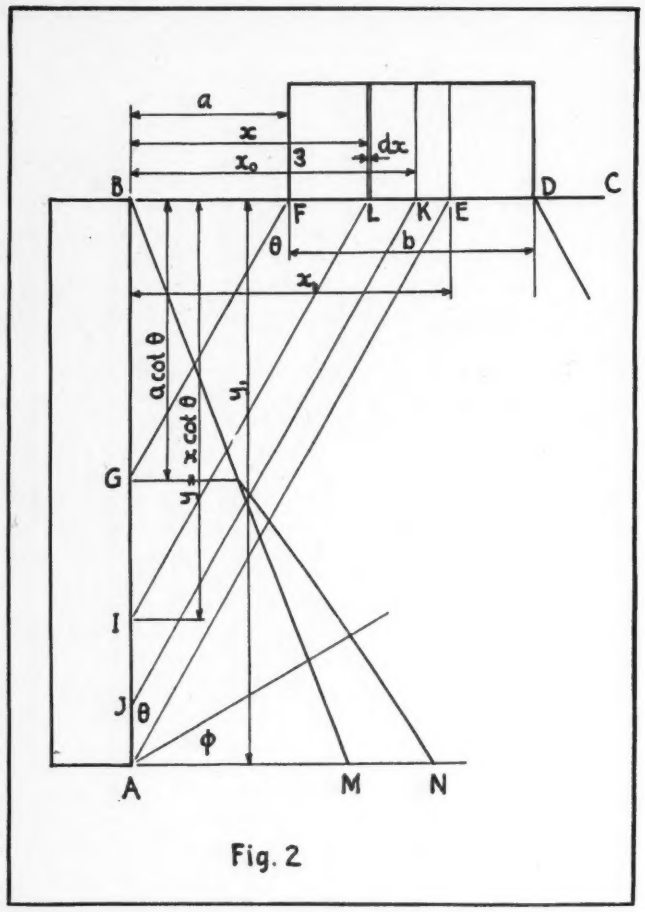


Fig. 2

reasoning, it can be shown that there is an upward shearing stress along the surface MN equal to the reaction that would be distributed along XN if there were no wall, or

$$J = \frac{Vy'}{2y}$$

in which J is the shearing stress.

Taking moments about the point N,

$$hy'.\ \frac{y'}{2} + V(y\tan\Theta - y'\tan\Theta) -$$

$$\tfrac{1}{2}V\left(1-\frac{y'}{2y}\right)(2y\tan\Theta - y'\tan\ \Theta) = 0$$

$$h = \frac{V\tan\Theta}{2y} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Experiments made to determine the angle of spread have shown that it is approximately 30°. The angle ϕ is also, more or less, 30°, except for unusual soils. In view of these facts, assumption (7) which states that $\Theta = \frac{1}{2}(90° - \phi)$ is justified as an approximation that will yield results sufficiently accurate for practical purposes.

Consider a vertical retaining wall AB, Fig. 2, with a level fill and a superimposed load W = wb. The thrust due to the level fill alone, calculated by Rankine's formula, is represented by the triangle ABM. It is now desired to find an expression for the intensity of thrust at any point in the wall due to the load W. Draw FG and AE making an angle Θ with the vertical. Since Θ is the angle of spread, any portion of the wall above the point G is not affected by the load W; that is, there is no lateral thrust between B and G due to the load W or any part of it. Similarly, that part of the load W to the right of E has no effect on the wall. Hence, the effective load is

$$W' = w(x_1 - a)$$

Take an infinitesimally small part of the load equal to wdx. This load wdx exerts a horizontal thrust dp on the wall at a point I a distance y from the surface within the area of spread. Substituting in formula (2),

$$dp = \frac{wdx\tan\Theta}{2y} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The intensity of pressure p_V at the point A for a load from F to E is the summation of the intensities dp due to all the loads wdx from F to E. Therefore, as x increases from a to x_1, p increases from 0 to p_V. Hence,

$$\int_0^{p_V} dp = \frac{w\tan\Theta}{2y_1} \int_a^{x_1} dx$$

$$p_V = \frac{w\tan\Theta}{2y_1}\ (x_1 - a)$$

But $y_1 = x_1\cot\Theta$, whence

$$p_V = \frac{w\tan^2\Theta}{2x_1}\ (x_1 - a)$$

which is indicated in Fig. 2 by the line MN. The intensity at any point between G and A can be obtained from this formula by substituting the value of x corresponding to the point, so that, in general,

$$p_V = \frac{w\tan^2\Theta}{2x}\ (x - a) \qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

If the load extends from F to a point K, so that $x_0 < x_1$, the intensity at A is the intensity due to a continuous load from F to E minus a continuous load from K to E, or

$$p_V = \frac{w\tan\Theta}{2y_1}\int_a^{x_1} dx - \frac{w\tan\Theta}{2y_1}\int_{x_0}^{x_1} dx$$

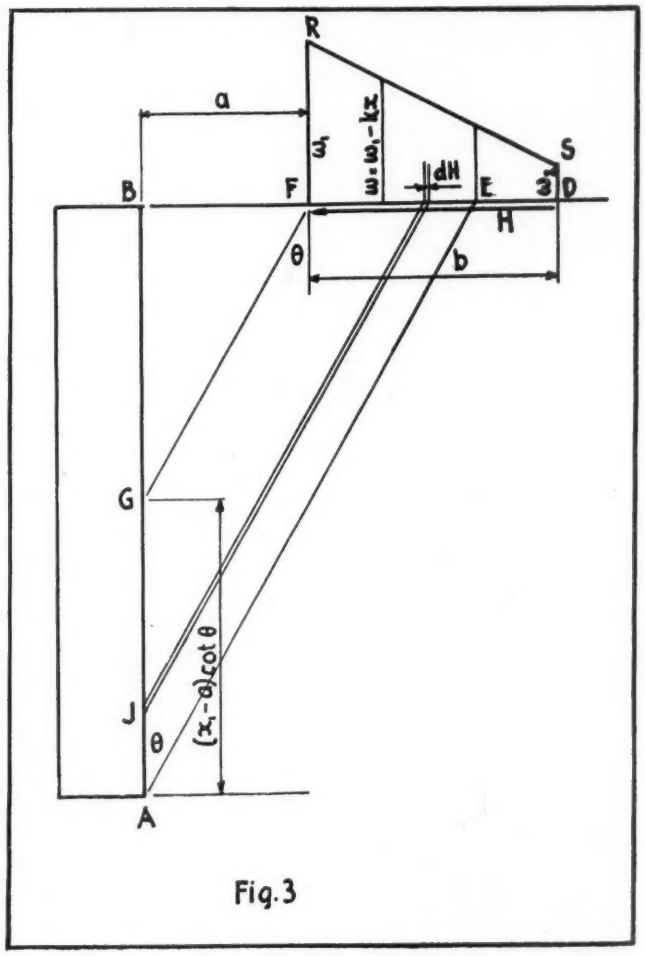


Fig. 3

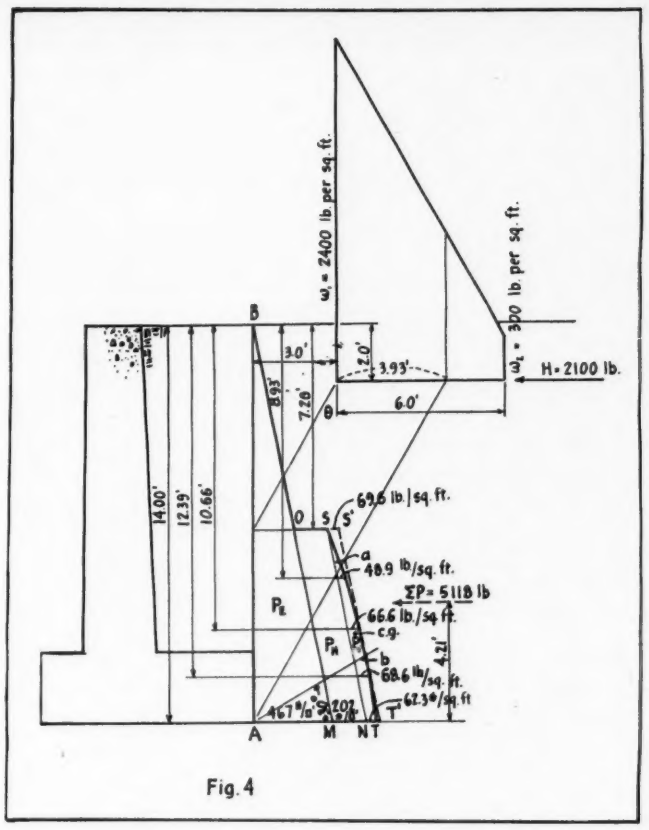


Fig. 4

$$p_V = \frac{w\tan\theta}{2y_1}(x_0 - a) = \frac{w\tan^2\theta}{2x_1}(x_0 - a)$$

In general, therefore, when the value of x is between x_0 and x_1

$$p_V = \frac{w\tan^2\theta}{2x}(x_0 - a) \quad \ldots\ldots(5)$$

For values of x between a and x_0, x_0 does not enter into the equation, since the portion of the load between L and K does not affect any part of the wall above I.

Consider, now, a vertical retaining wall surcharged by a load of variable intensity w. Here w is a function of x. Suppose $w = w_1 + kx$. Then,

$$dp = \frac{\tan\theta}{2y_1}(w_1 + kx)dx$$

$$= \frac{w_1\tan\theta}{2y_1}dx + \frac{k\tan\theta}{2y_1}xdx$$

$$\int_0^{p_V} dp = \frac{w_1\tan\theta}{2y_1}\int_a^{x_1} dx + \frac{k\tan\theta}{2y_1}\int_a^{x_1} xdx$$

$$p_V = \frac{w_1\tan\theta}{2y_1}(x_1 - a) + \frac{k\tan^2\theta}{4x_1}(x_1^2 - a^2)$$

which is the expression for the intensity of pressure at the point A. In general, therefore,

$$p_V = \frac{w\tan^2\theta}{2x}(x - a) + \frac{k\tan^2\theta}{4x}(x^2 - a^2) \quad \ldots\ldots(6)$$

which is the expression for the intensity of pressure at any point between G and A.

If x lies between x_0 and x_1,

$$p_V = \frac{w\tan^2\theta}{2x}(x_0 - a) + \frac{k\tan^2\theta}{4x}(x_0^2 - a^2) \quad \ldots\ldots(7)$$

Consider, now, a vertical retaining wall retaining a level fill on which is superimposed a second retaining wall. Since this second wall is subjected to horizontal as well as vertical loading, the resultant on its base is inclined to the surface of the earth and can be resolved into its vertical and horizontal components. In Fig. 3, the pressure diagram FRSD, in which $w = w_1 - kx$, represents the vertical component, and the force H acting along the base FD represents the horizontal component.

The intensity of lateral pressure against the primary wall AB due to the vertical component can be determined by formula (6), in which $-k$ is substituted for $+k$, since the vertical pressure decreases as x increases.

Since the force H acts in combination with FRSD, it may be assumed that it is distributed uniformly along the base. With each vertical element wdx there is a horizontal element dH. Therefore, at any point J in the wall AB there is a lateral thrust dH acting over a height $dy = \cot\theta\, dx$. The portion ED of the force H has no effect on the portion GA of the wall. Let H′ be that portion of H that acts between F and E. The intensity of lateral pressure against the wall due to dH is

$$p_H = \frac{dH}{\cot\theta dx}$$

whence

$$dH = p_H\cot\theta dx$$

$$\int_0^{H'} dH = p_H\cot\theta\int_a^{x_1} dx$$

$$H' = p_H\cot\theta(x_1 - a)$$

$$p_H = \frac{H'}{\cot\theta\ (x_1 - a)}$$

But

$$\frac{H'}{H} = \frac{x_1 - a}{b}$$

whence

$$H' = \frac{H(x_1 - a)}{b}$$

Substituting,

$$p_H = \frac{H}{b\cot\theta} = \frac{H\tan\theta}{b}$$

That is, the thrust is uniformly distributed along the vertical wall.

(*Continued on page 130*)

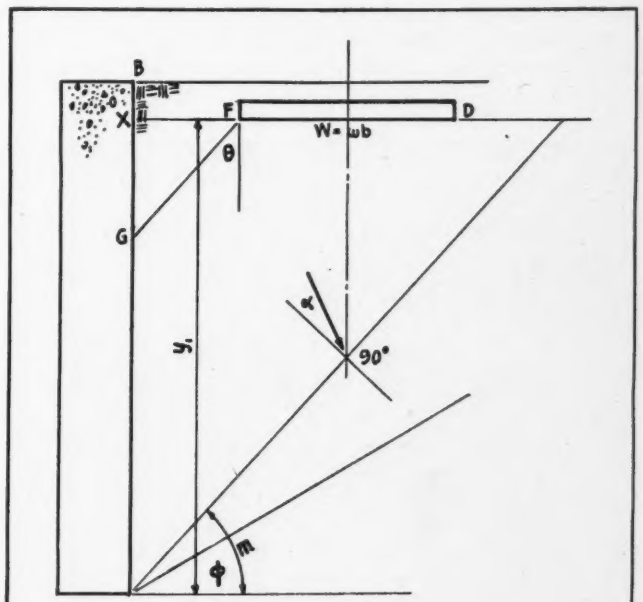


Fig. 5

Sources of

TITANIUM PIGMENTS

— *Black Beach Ores*

By J. L. GILLSON and J. E. BOOGE

TITANIUM is the 9th most abundant chemical element in the earth's crust and titanium is present in all rocks. Minerals, however, in which titanium is present in sufficient abundance to make them of commercial importance, are few in number; ilmenite ($FeOTiO_2$), rutile (TiO_2), titanite ($CaOTiO_2SiO_2$), and perovskite ($CaOTiO_2$). The most important of these is ilmenite, which should, according to its chemical formula, carry 52.6% TiO_2. Actually, owing to the presence of excess iron oxide, either as distinct grains of an iron mineral intimately intergrown with the ilmenite, or as a chemical replacement, much of the known ilmenite carries less than the theoretical amount of TiO_2. A few ores carry more than 52.6%, owing to the presence of excess TiO_2, presumably substituting in the molecule for some of the iron oxide, or possibly in some instances, as sub-microscopic inclusions of rutile in the ilmenite.

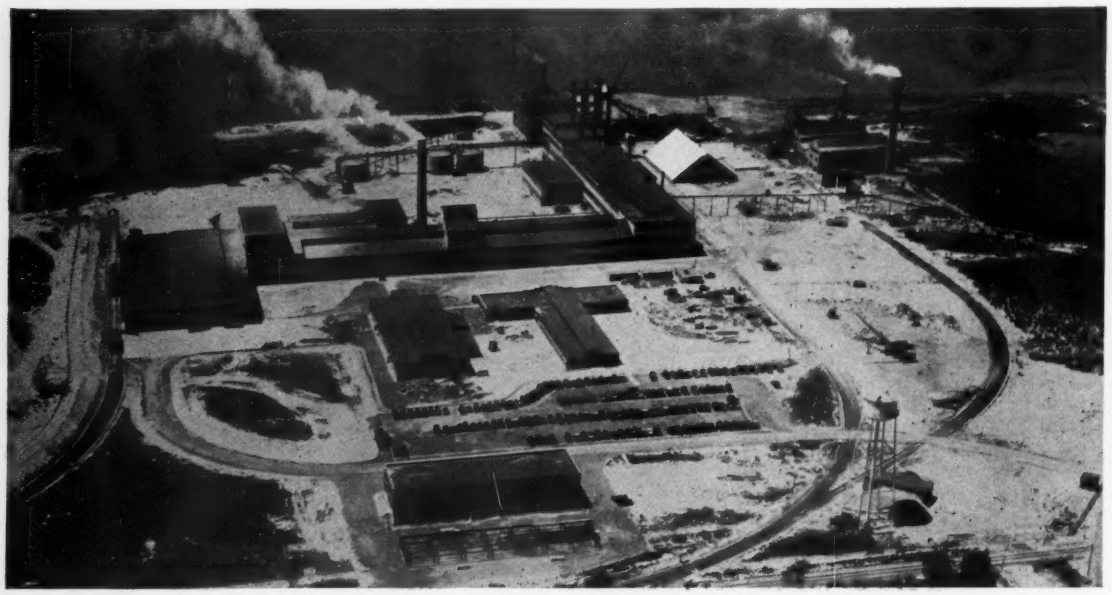
Ilmenite ores are of two distinct types, rock ores and sand ores. The rock ores are masses, more or less rich in ilmenite and of various sizes and shapes, found in some rocks in various parts of the world. In most of such masses, the ilmenite is subordinate in quantity to magnetite (Fe_3O_4), and such ores are known as "titaniferous magnetites." In a few ore bodies, ilmenite is the principal metallic mineral of the ore. Such rock ores are known in Virginia, Quebec, and Southern Norway.

The sand ores are ocean beach sands, lying on the shores of tropical countries, the country rock of which is one that carries a little disseminated ilmenite. The deep weathering of this rock under tropical conditions decomposed all of the relatively soluble minerals, including the magnetite, and left the very insoluble ones concentrated in that type of soil known as laterite. Erosion by the streams carried the undecomposed minerals of the laterite to the sea, in which the heavy ones were at once deposited near shore, and the light ones were carried further out. Owing to sorting by wave action the heavy minerals were concentrated in favorable places on the beaches close to the mouths of the streams down which the material was brought from the interior. Such beaches are black, instead of white or yellow as are most beaches, and present a very striking appearance. The black mineral is the ilmenite, and the variety found in such beaches is invariably of high quality.

Many such deposits are known, but the largest and most extensively exploited ones are on the shores of the Arabian Sea, in the State of Travancore, on the west side of the Indian sub-continent, near its south end. Formerly these deposits were not worked for the ilmenite, but for another mineral found in them, monazite, a phosphate of the cerium metals, carrying also thorium. From the thorium oxide, thorium nitrate was made, the essential raw material for incandescent gas mantles.

Travancore, like the other native states of India, is ruled by a Maharajah, and the British Government of India exercises only nominal control. Travancore is about the size of the State of Massachusetts, but has a ten per cent greater population, largely rural. The people are of Dravidian stock, speaking Tamil in the South and Malayalam in the central and northern parts of the state. The two dialects are mutually understandable, but the written language is not. The climate of Travancore is a marine one, hence equitable, and Travancore might be called the "California" of India. The country is scenic, with mountains rising to a height of 5000 feet only a few miles back from the coast.

The black sands of Travancore are found at two places, separated by about 80 miles of coast on which no commercial deposits are found. The southern black beach is near a little town called Manavalakurichi, a name corrupted to "M.K." by the European population. The northern deposit extends northward from the mouth of an estuary called Neendakara to Kayankulam Bar, a distance of 15 miles. Neendakara is the harbor of Quilon, which was, in the time of Marco Polo, one of the busiest ports of the world. The Venetian sailors



Factory of the Titanium Pigment Company, at Sayreville, N. J.

—Paint, Oil and Chemical Review

and "Nestorian Christians" (from Syria) came to Quilon and other ports on the southern west coast of India, the "Malabar" coast, and there traded with the Chinese who brought silks and spices there in their unwieldly junks. Authentic records state that junks large enough to carry 700 people came into the harbor of Quilon. The harbor entrance has since been closed by sand bars, and only very small vessels can now enter.

Pigments based upon Titanium Oxide were first manufactured in this country shortly after 1920. The extended pigments containing 25 — 30% of TiO_2, the remainder being barium sulfate or calcium sulfate, were first produced, to be followed later by pure TiO_2. The extended pigments were easier to produce with satisfactory quality and possessed adequate hiding power for the applications desired at the time. Pure TiO_2 was manufactured in this country on a large scale beginning in 1928 and has increased very rapidly in production and use since that date. Numerous patents have been issued covering both the manufacturing processes and uses of these pigments.

The two essential raw materials are ilmenite ore and sulphuric acid. A considerably greater weight of sulphuric acid is required than of the ilmenite ore. The first step in the process is to "attack" or sulfate the ilmenite ore by treatment with strong sulphuric acid, converting to sulphates the titanium and iron oxides. The reaction is exothermic and once the temperature necessary for the initiation of the reaction has been reached, the ore and acid react vigorously with evolution of considerable heat and sulphurous gases.

The attack mass, comprising the sulphates of titanium and iron, is next dissolved and the ferric sulphate resulting from the presence of ferric oxide in the ilmenite is reduced to the ferrous condition. The resulting solution of titanium and ferrous sulphates contains considerable amounts of unattacked ilmenite and impurities in the ilmenite partly, in the form of slime. This titanium solution must be clarified to remove the insoluble material prior to hydrolysis. The solution is then hydrolyzed under carefully controlled conditions to precipitate a hydrous form of TiO_2.

This precipitate is washed and calcined to produce the regular pigment grade of titanium dioxide. The calcined pigment is ground to eliminate the grit and sandiness developed during the calcination.

Due to the fact that titanium previously was regarded as one of the rarer elements, the complicated reactions of its compounds were not thoroughly studied or well understood. It is not surprising therefore, that the development of processes for production of TiO_2 pigments of the highest grade required intensive research. Many fundamental points have been established affecting quality and control of uniformity.

TiO_2 is used wherever a white pigment of maximum whitening or hiding power is required. Its hiding power and tinting strength are approximately 400 as based on lithopone as 100 (altho dependent upon conditions of use). The next "strongest" pigment, zinc sulphide, rates approximately 240. The rapid multiplication of hiding power with increase in refractive index is illustrated by the following table:

	Hiding Power	*Ref. Index*
ZnO	90	2.02
ZnS	240	2.37
TiO_2	400	2.53

As no white compound capable of economical manufacture is known with a refractive index higher than that of TiO_2, the latter is believed to have a permanent place in the white pigment field.

The use of TiO_2 by different industries is surprisingly varied. The paint industry consumes the major portion, white paper, rubber, linoleum and oil cloth, rayon, ceramics, leather and shoe dressings consume this product in smaller amounts.

Obviously TiO_2 is a superior pigment where low pigmentation is desired as in paper where high pigment content may decrease tensile strength, in Rayon for similar reasons, in many rubber compounds, white leather finishes, and textile uses.

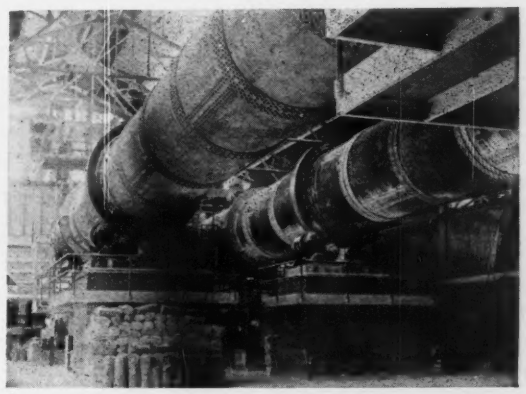
In the paint field high hiding power or "single coat" paints and enamels are becoming more and more popular. These are usually pigmented with TiO_2. For example, the newer one-coat enamels are becoming very popular. They are usually quick drying and are often based upon use of synthetic resin vehicles. TiO_2 is also invaluable in baking enamels for electric refrigerators. High hiding outside house paints are growing in popularity. These contain TiO_2, leaded zinc oxide and extender. The hiding power may be varied by use of more or less TiO_2 as desired.

For evaluation of various pigments in outside house paints one large titanium pigment manufacturer maintains paint exposure farms near Wilmington, Del., near Canon City, Texas, and at Hialeah, Fla. Promising formulas are further evaluated by practical house painting tests in various parts of the country. The results obtained are at the disposal of the paint trade.

One popular form of titanium pigments has been the type extended with barium sulfate or calcium sulfate. These are known as "Titanium Barium Pigment" and "Titanium Calcium Pigment", respectively. The titanium barium pigment sold in this country contains approximately 25% TiO_2 and 75% barium sulfate; the titanium calcium pigment contains approximately thirty percent TiO_2 and 70% calcium sulfate. Other combinations including 50% TiO_2 and 50% extender have been sold abroad but not to any extent in this country.

The extended titanium pigments are used in applications where the maximum hiding power of the straight TiO_2 is not required, but where the high brightness, cleanliness of tints, and resistance to yellowing in the dark, of a titanium pigment is desired. Most paints, both for inside use and outside use, are formulated for application of two or more coats. In outside paints this has the advantage of making necessary the application of a sufficient thickness of paint film to allow good durability. For inside paints one coat is sufficient in most cases, when applied over a white or light colored surface, two coats being required to cover entirely surfaces offering too great a contrast.

In flat paints the pigmentation is increased so that the pigment extends to the surface of the film and causes surface irregularities. The amount of vehicle present is such that it will bind together the pigment particles but will allow these particles or flocculates of these particles to extend to the surface and destroy the specular reflection obtained from an enamel film.



Paint, Oil and Chemical Review

Partial view of the calciners at the Titanium Pigment Company.

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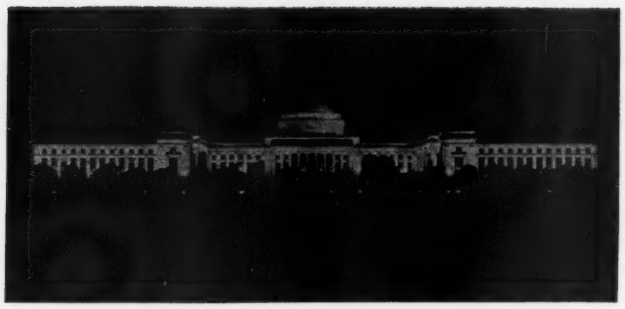


EDITORIALS

FOR THE FIRST CLASS MAIL

AIR transportation has progressed in speed and reliability to a point where it is capable and ready to carry all long haul first class mails in the United States. Besides facilitating commerce to the point of overnight mail service between any two important cities in the country, immediate employment would be provided to scores of aeronautical engineers, mechanics, and pilots.

The loss of first class mail revenue would not be much of a blow to the railroads as their compensation for carrying all classes of mail constitutes about 2½ percent. of their entire revenue and they would still be reserved for all other class mail and for first class mails on short hauls where there is no time saving benefit derived from air carriage. The backbone of the railroads has been and will continue to be their freight which accounts for approximately 90 percent. of their revenue. Some railroad men agree that if they could get rid of their fast haul passengers, of which the airlines are now relieving them in large numbers, and the fast mail, then operating expenses could be materially reduced thus allowing the inauguration of lower freight rates to overcome successfully truck freight line competition.

This system of air carriage of all first class mails is not an original idea. England has in operation a postal system in which all first class mail travels by air when the destination of the parcels or letters is at a distance, whereby timesaving will be the result of air transportation.

In times of emergencies the values of this system would well repay the small additional cost. We would not only have a giant fleet of planes easily convertible into military planes but we would also have a corps of well trained pilots to fly them for the protection of our country if a condition necessitating military action should ever arise.

During the past the United States Government has taken advantage of the speediest dependable mode of travel available for the transportation of first class mails. Today with air transportation established as a dependable service and ready to carry the mails over the continent at over 200 miles an hour, the first class mails travel across the country at an average of under 45 miles an hour. True, there are no planes being flown today with compartments that could take care of the weight of the transcontinental and other long haul mails, but if a market for such planes developed existing designs could be altered so that within six months a fleet of planes, each capable of economically carrying two tons of mail, would be flying the skyways of America.

THE CASE FOR STEAM

THE American public is somewhat mistaken in the prevalent belief that the Diesel and electric locomotive will soon supplant the steam locomotive. There are still many obstacles in the way of the Diesel and, from the economic point of view, the steam locomotive today is a more serious competitor of the electric engine than it was thirty years ago. This statement comes authoritatively from an official of one of the largest locomotive construction firms.

A survey shows that the average scheduled speed of steam trains is considerably greater than that of the Diesel trains, despite the fact that the steam-drawn loads are many times greater. A technical inspection shows too, that the tractive power of the Diesel is less than that of the steam locomotive at speeds above 20 m.p.h. Coupled with this is the fact that a Diesel costs three times as much as a comparable steam locomotive and that its upkeep mounts quickly after the first year of operation. Greater fuel economy with the Diesel is recognized, but its continuance is problematical; that is, more so than the continuance of a cheap coal source. A negative aspect of the case shows that steam is being judged unfairly, since 91% of our present locomotives were bought before "this present era of improvement". Lastly, the passengers' demand for greater riding comfort has been met with universal air conditioning, so that the soot question is removed.

Americans are not afraid to make a change; but if a revolutionary change is to be made, it must be based on sound reasoning, and that is not entirely the case with the Diesel. So, remembering that the railroads have invested heavily in steam equipment, and considering the few facts put forth here, we may cast aside for quite a while any visions we may have of the Diesel engines displacing the steam locomotive.

THE STRONGEST ALLIANCE

TODAY Italy, because of her proposed aggrandizement of Ethiopia, has received from the League of Nations a denunciation similar to that given to Japan and Germany. The League, however, realizes the ineffectiveness of its former action and is shaking a bigger stick, economic isolation. Although to the pacifist the use of such a weapon for the first time in modern history may be heralded as an indication of world outlawry of war, he must admit that the cause of this outlawry is but a manipulation on the part of the leading nations of the world to maintain their present status. It is interesting to note that the two most active leaders in the League of Nations, Britain and France, are also the nations who received the largest grants from the Treaty of Versailles. Following them are several other nations which owe their existance to some similar treaty signed at the close of the World War. Nations such as Germany and Russia who were distinctly penalized remain apart from the League. Fortunately, most of the nations are in agreement with the League and follow the leadership of the more interested nations in that group.

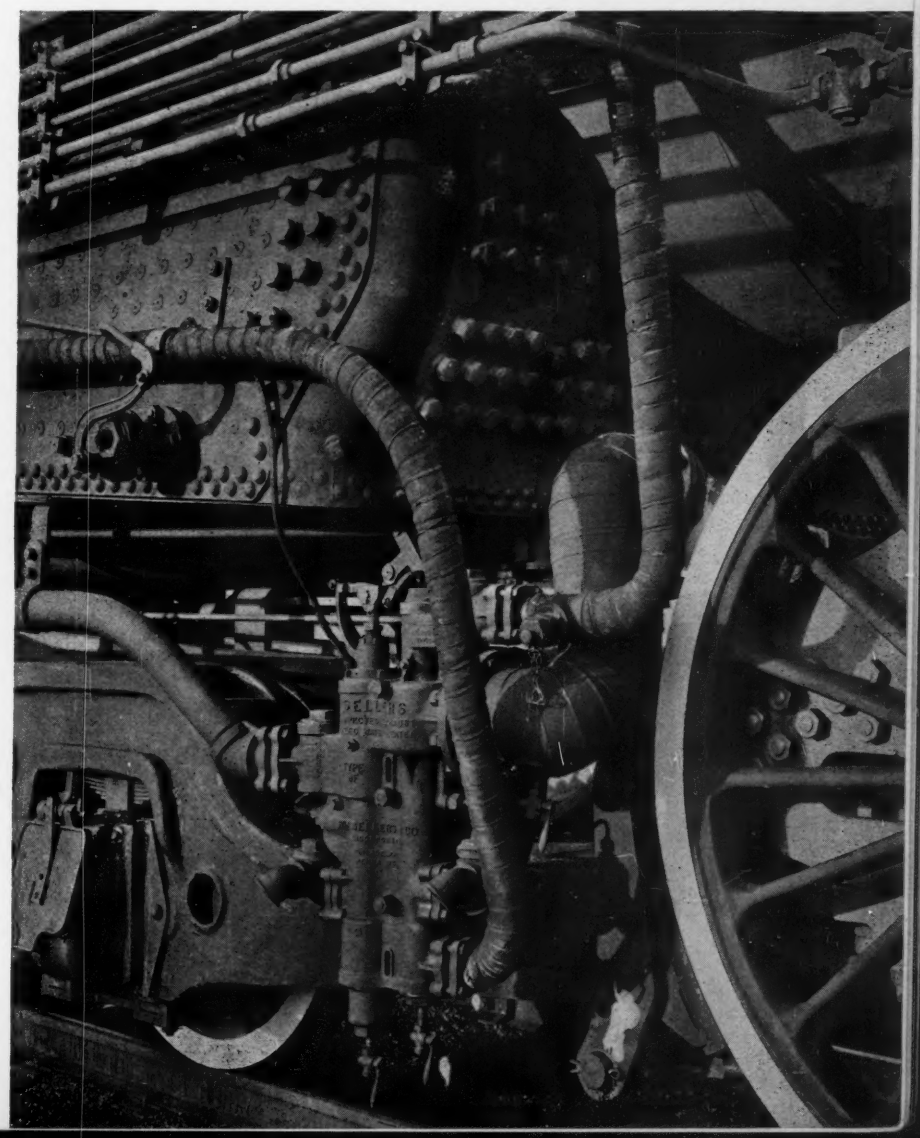
The more detailed the study, the more one realizes that the League does not exist for any idealistic aim but receives its stimulation from nationalistic fears. Even though this is far from the idealism of the League's originator, from a worldly viewpoint the League may possess a common bond as strong as the present race of men will permit. If it will follow the plan of economic isolation, which the economist has held to be the most effective way to defeat an army, the League may turn out to be the strongest international alliance that exists. It has a common unity and an offensive machine that cannot be matched.

The present Italian crisis offers the League a chance to assert its real power, and if it is successful in diverting Italy from her present path, either by embargo or threat of embargo, it may be credited with more strength than any army in Europe. A successful demonstration would give new aspects to the League's place in international affairs, and perhaps in world history.

Unfortunately, it would seem that the only way to preserve peace is for those nations which have captured the world's resources to keep them. The League must back those nations in saying, "we've got them and we are going to keep them". This will be hard on Italy, Germany, and Japan but if the League is to become a power for world good it must first consolidate the nations against war.

ANNOUNCEMENT

THE Managing Board takes pleasure in announcing the following promotions: Martin A. Gilman, '36, to the position of Business Manager left vacant by the resignation of Robert E. Williams, '36; John B. Allen, '36, and David A. Werblin, '36, to the positions of Art Editor; and John C. White, '38, to the position of Assistant Circulation Manager.



ENGINEERING DIGEST

SALT PRODUCTION

NEW methods of securing and refining salt have recently been developed in this country. The Frasch method of mining sulfur has been adapted to the mining of rock salt, and is being used along the Atlantic coastal plain.

On the west coast, the Alviso Salt Company has introduced and patented a revolutionary process. On a 15,000 acre expanse of marsh land, canals and levees have been constructed, dividing the land up into shallow ponds. Ocean water is admitted to these ponds at high tide, and is then evaporated by the sun, leaving a deposit of salt. This process is repeated several times until there is a salt crust several inches thick on the bottom of the ponds. Next, a specially fitted Caterpillar tractor, equipped with cutters, elevators, and other machinery, is driven along the dry bed of the pond, tearing loose the salt deposits and discharging them on a huge sectional conveyor, which leads to a 600-ton barge in the nearest canal. When loaded, the barge is towed to a washing plant, where the salt is discharged into an elevator, and carried up through a series of filters, washers, and driers. The refined salt is now ready for distribution as coarse salt, or, after further washing and screening, for table use.

The new free-running salt has been prepared by boiling a raw salt solution at low temperatures in a partial vacuum. Cattle- and dairy-men can now buy hydraulically-produced salt blocks which wear longer and offer more resistance to weather conditions.

Thus salt production has been improved, and at the same time the cost of production has been lowered.

—*Journal of Chemical Education.*

ALUMINUM PAINT

AFTER much debating, the new San Francisco-Oakland Bay Bridge is being given a final coat of aluminum paint. There was some disagreement between the architects and the engineers of the bridge; one favored gray paint for appearance and the other black paint for durability. A happy medium was found in aluminum paint.

The bridge required an extensive painting: first, two coats of red lead, then a black graphite coat, and now a coat of aluminum paint. Both the engineers and the architects connected with the bridge feel that this combination will furnish maximum endurance and attractive appearance with a minimum of maintenance.

—*Scientific American.*

HCN AS A FUMIGANT

INSECT infestation of imported dried fruits, such as dates and currants, can be effectively dealt with only by vacuum fumigation, and this with HCN gas. Only this gas was capable of killing the larvae of the fig moth in the center of a 70 pound case of dates. Liquid HCN boils at about 80°F. at 1 atmosphere pressure.

—*Food Industries*

AIR CORPS PIONEERING

WRIGHT FIELD, the Army Air Corps Engineering Center, is perhaps the world's greatest aeronautical research and experimental establishment. Although it is a military establishment, manufacturers are privileged to go there with their new planes and have them tested and passed upon.

At the present time competitions are going on in four classes of military planes — pursuit, attack, bombing, and training — and a study of the planes undergoing test reveals an interesting thing: the biplane, as far as the United States Army Air Corps is concerned, is through. In all classes the craft under test are monoplanes. The performance of these machines is to be regarded as confidential; however, it is no secret that almost within a period of months the speed of the combat-type machine has gone from under 200 miles an hour to more than 250 miles an hour and is rapidly approaching 300.

The airplane shown is the Boeing 299 Bomber, the prototype of which met with an unfortunate mishap during tests at Wright Field.

—The New York Times

NON-DIRECTIONAL MICROPHONE

AN improved moving coil, non-directional microphone has recently become available. This new instrument is mounted in a spherical housing, which shape tests showed to cause the least directional reponse. The diaphragm is mounted in a horizontal plane so that the response is perfectly uniform for all horizontal angles. The slight directional effect in a vertical plane is compensated for by mounting an acoustic screen in front of the diaphragm. Because of the new shape, extensive changes had to be made in the internal construction in order to even out the response curve of the microphone and to produce a durable, shockproof unit.

—Bell Laboratories Record.

HIGH VOLTAGE MEASUREMENT

VOLTAGES which exceed 30,000 have hitherto been measured by needle and sphere spark gaps, but recently the Electrical Engineering Department at the California Institute of Technology has developed apparatus which promises to supplant both of these methods.

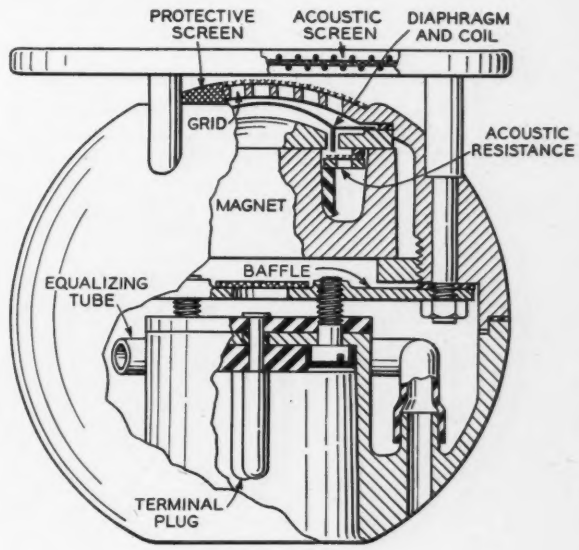
The new apparatus depends on the attraction between two charged spheres, when they are far enough apart so as not to allow the spark to jump the gap. There is a mathematical formula connecting the force on one sphere and the voltage causing it, so that, if the force is determined by experiment, the potential difference may be calculated.

Two cast-aluminum spheres of one meter diameter are supported horizontally. One sphere is insulated and fixed, the other is grounded and movable. Motion of the grounded sphere, as it is attracted to the insulated one, is seen through a telescopic arrangement, a thin line on the sphere being the focusing point. A weighing pan is connected by a light cord to the grounded shaft, and, if any off-balance is observed, weights are added to the pan. The voltage difference is easily calculated from this data.

—Electrical West.

ROBOT RAT

DR. STEVENSON'S "Mechanical Rat" is a small three-wheeled "roller skate," loaded with switches, electromagnets, and small motors. It is set on a track with twelve forks, in each of which the wrong turn leads to a dead end. The robot is set to take a right turn at every fork. When it does and hits the dead end, it reverses, goes back past the fork and makes the correct left turn. This sets the controls in such a way that on a second try it will make every turn correctly. The inventor claims that the robot remembers what it has learned much better than any man or animal.—*Time.*



RESEARCH IN REVIEW

COURSE VIII — Physics

FOR several years Professor Harrison has been building unequalled equipment for photographing, measuring, and analyzing spectra. The 35-foot 180,000-line grating in the Spectroscopy Laboratory is as powerful as any in the world, and is decidedly better than the ones which have been used for the determination of most of the standard wavelengths now in use. An automatic wavelength-measuring engine, which has been constructed during the past year, makes it possible to measure the spectrum photographs, apply the necessary corrections to convert the readings into wavelengths, and come out with a printed list of wavelengths, almost completely automatically, in a small fraction of the time formerly required to do the same things by hand, and with decidedly improved accuracy through the elimination of the personal equation. The interval sorting device, a great help in the analysis of the resulting spectrum, has been in use for several years, but has been limited in its application because it requires very accurate wavelengths to be of the greatest service, and such wavelengths have not been previously available, though the new facilities of the Spectroscopy Laboratory permit them to be obtained. With all this in mind, it seems to be an appropriate time to undertake a wholesale job of remeasuring the spectra of the elements with the new methods, obtaining both improved accuracy and an increased number of lines. Under the direction of Professor Harrison about a dozen E.R.A. workers have been continuously assigned to the measuring, computing, and tabulating work. A number of staff members, including teaching fellows and assistants, are taking the pictures. The project may continue most of the year, and if it does, it should yield a complete and entirely new set of data for the line spectra of the elements, amply justifying all the pains which have been taken in the development of the Spectroscopy Laboratory.

Many other research developments in the physics department are of interest. Professor Van de Graaff has just returned from Russia, where he has been inspecting high voltage work along the lines of his own research. Professor Boyce will be absent for the second half year and next summer, with the Harvard College Observatory expedition, to study the solar eclipse in Siberia in the summer of 1936. Professor Vallarta is on leave for the year, working in Louvain, Belgium, on the theory of cosmic rays in collaboration with the Abbé Lemaitre.

COURSE V — Chemistry

THE research program of Course V has been given additional impetus with the arrival of three new members on the teaching staff.

Dr. J. Lawrence Oncley, a new member of the teaching staff for inorganic chemistry, is continuing his earlier research on the measurement of the dielectric constants of pure gases and mixtures of gases, under pressures ranging from 10 to 250 atmospheres. It is expected that this work will lead to a better understanding of the dielectric behavior of liquids. Studies on the dielectric properties of colloidal solutions are included in the program.

Dr. Oncley was a National Research Fellow at M.I.T. from 1932 to 1934. Last year he was back at his alma mater, the University of Wisconsin, engaged in teaching and research. He has had experience, also, in the Research Laboratory of the General Electric Company where he measured the dielectric properties of some insulating oils.

Dr. Lawrence J. Heidt comes to Technology as an instructor in freshman chemistry after five years as a research associate in the field of photochemistry in the Harvard Chemical Laboratories. He completed work for his doctorate at the University of Wisconsin, with a thesis on photochemical technique and the photolysis of hydrogen peroxide. Here, at M.I.T., Dr. Heidt is carrying forward research on the photochemical decomposition of ozone in the presence of water, with the object in view of obtaining a better understanding of the mechanism by which hydrogen and oxygen combine to form water. Further studies on the photochemical decomposition of azo-methane are planned by Dr. Heidt.

Robert C. Hockett comes to the chemistry department as assistant professor after six years of research on sugars in Washington where he was an associate on the staff of the National Institute of Health of the United States Public Health Service. In addition to his duties on the teaching staff of organic chemistry, Professor Hockett is inaugurating a study of the whole field of the tetrose or four-carbon sugars. While this problem is aimed at synthesizing the little known and the unknown, but predictable, members of this group of compounds, it has a further significance inasmuch as the tetroses are possible intermediates in the break-down of glucose in supplying energy for the life processes of both plants and animals.

COURSE I — Civil Engineering

DURING the past year a new shaking table, capable of reproducing arbitrary motions such as occur in earthquakes, has been designed and is being built by Mr. A. C. Ruge in the Seismology Laboratory. While the table is not as yet completed, the work has progressed to a point where the validity of its design principles has been demonstrated. Research dealing with the effect of earthquakes upon elevated water tanks, begun in the spring of 1934, is continuing, the earlier work having led to the development of several new types of tower design.

Construction of the new machine designed for the solution of nine linear simultaneous equations is progressing under the direction of Professor J. B. Wilbur. Assembly of the machine will begin within the next month.

For research in concrete during the past year, Professor R. W. Carlson chose as his objective the investigation of shrinkage as effected by cement content, water consistency, and by the type and amount of aggregate used.

Research in the Soil Mechanics Laboratory has continued under the direction of Professor G. Gilboy. Among the problems which have been recently investigated are the flow of water through earth dams and pervious foundations, the flow of water into wells, lateral earth pressure by mechanical analogy, and the distribution of wheel-load pressures under flexible pavements.

Professor G. E. Russell is initiating a study of pipe coefficients. Approaching the problem from the angle of the Reynolds Number, data made available recently are being analyzed, with the effect of the aging of pipes upon pipe coefficients as his objective.

COURSE XI — Sanitary Engineering

EXPERIMENTAL studies of the time rate of solution of lump filter alum suspended in moving water were made under the direction of Professor T. R. Camp. It was found that the rate was unaffected by conditions of storage of the alum, by the time of immersion or by the concentration of the solution up to about eight per cent. The rate at room temperature was found to be from 0.2 to 0.3 mg. per sq. cm. per second for velocities less than 5 cm. per sec. and to increase rapidly for higher velocities. It is planned to continue these studies on other chemicals used in water and sewage treatment.

In studies of the head losses around the 180° bends of baffled mixing chambers of the "round-the-end" type, it was found that the loss per bend is about 3 to 4 times the velocity head in the straight channel.

COURSE XVII — Engineering Construction

THE work of the Masonry Material Research Laboratory for the past year has been directed mainly toward a study of the volume changes in brick and mortar and their effect upon extent and continuity of bond.

A series of experiments in which various mortars have been subjected to movements of varying amounts at varying times has been completed and the results are now being studied in connection with the separate volume change determination for the materials themselves.

Current tests in connection with the study of the effect of colorless waterproofings on brick and mortar assemblages, now in the third year, have been completed. This series will not be completed until 1938. Additional petrographical data on the "bond-layer" are being required in connection with the one-year specimens made last year by the continued study of thin sections through mortar joints. Professor W. C. Voss is in charge of this research.

COURSE X — Chemical Engineering

MR. Squires and Dr. Brown have approached the difficult problem of gelation by a study of the behavior of highly plastic clays, particularly at extremely high dilutions. The former has studied the influence of chemical conditions on the physical properties of the suspensions, and the latter has been examining them microscopically. Characteristics of the gels indicate that they possess a relatively rigid continuous mechanical structure, and yet highly plastic clays show definite gelation at concentrations as low as one-half percent of clay by volume. The difficulty lies in explaining the existence of a continuous mechanical structure at such low concentrations, despite the plate-like shape of the ultimate particles of the clay. Even more complicated is the effect of minute quantities of addition agents to the clay suspensions.

The investigation of plant problems in the School of Chemical Engineering Practice has been stimulated by the greatly increased enrollment of graduate students. Noteworthy accomplishments are increases in the efficiency of distilling light oils obtained from a by-product coke plant, the development of much-needed controls for the production of sodium sulfide, and a thorough study of pulp drying. Large-scale furnace tests have contributed to the confirmation and elaboration of theories of furnace design.

The Applied Chemistry Laboratory has been conducting a research program on the practical utilization of the lower olefines which are abundantly available in the gases produced in petroleum refining. This program has been developed along two main lines: (1) the polymerization to higher boiling hydrocarbons, and (2) conversion to basically important organic compounds, such as ethers and alcohols.

The general research program on drying is being continued with studies of the drying of various industrially important materials. As a result of recent work, a simple process has been developed which reduces the time required to dry heavy sole leather from eight days to a few hours.

The factors influencing the diffusion of various solutes through the liquid film at a gas-liquid interface is being studied as part of a doctor's thesis, in conjunction with the more complicated problem of simultaneous diffusion and chemical reaction in the liquid phase.

Recent research in the field of fuel utilization includes further studies in combustion and radiant heat transmission. The basic data for evaluating radiant heat transmission from gases have been broadened by the study of the radiating and absorbing characteristics of carbon monoxide, and by the extension of the temperature range of the data on carbon dioxide and water vapor.

COURSE VI — Electrical Engineering

THE visitor to Building 20 at the Institute will find himself surrounded by a miniature Cape Cod Canal, and portions of a miniature Buzzards Bay and Cape Cod Bay. But the miniature moon to cause the miniature tides so essential to the studies being made there is absent. In its place are electrical controls which make the water levels in the two bays at the ends follow faithfully in miniature the actual tides in nature, in order that certain data requisite to improvements in the canal can be accurately determined. The control apparatus, developed by members of the Department of Electrical Engineering in co-operation with the Department of Civil Engineering serves to control the water levels in either bay in accordance with a cam on which is cut the particular tidal curve to be reproduced. The device which reads the water level or rather the difference between the level called for by the cam and the actual level at any instant uses the water surface as one plate of a condenser, thus avoiding all the uncertainities occasioned by surface tension. This condenser, through a single amplifier tube, controls thyratrons which in turn drive a motor in one direction or the other according as the water level is above or below the level it should be at that instant. This motor lowers or raises a weir that spills water from the bay thus causing the water level to be adjusted toward the required level. As in practically all automatic control units, the real problem is to make the operation non-hunting and at the same time sufficiently rapid to give the desired accuracy. This is achieved by incorporating suitable antihunting elements at proper places in the dynamic system. With relatively simple automatic control apparatus the error in level can be reduced to about 5 or 10 percent. of the value it would have in the absence of such control. By operating the values supplying water to the bays from the same main time drive that rotates the cams, the levels in the bays can be made to approximate the desired tides within about 10 or 15 percent. without automatic control. The combination thus gives water levels that differ from the desired levels within about one percent of the tidal range which is adequate for the studies to be made.

LATERAL PRESSURES

(*Continued from page 121*)

The total intensity of thrust against the primary wall at any point is, therefore,

$$p = p_E + p_V + p_H$$

To illustrate the application of these formulae, the following example is worked out.

Problem.—Determine the lateral thrust and point of application against a retaining wall loaded as shown in Fig. 4. Weight of earth is 100 lb. per cu. ft. and $\phi = 30°$.

Solution.—

$$w_1 = 2400;\ a = 3;\ k = \frac{2400-300}{6} = 350;$$

$$\Theta = \tfrac{1}{2}(90° - \phi) = 30°;\ \tan\Theta = 0.5774;\ \cot\Theta = 1.732;$$

$$p_E = \frac{1-\sin\phi}{1+\sin\phi}\,wh = \tfrac{1}{3}\,(100)14 = 467 \text{ lb./sq. ft.}$$

Using a convenient scale, on a horizontal line from A plot the point M so that AM = 467 lb. and complete the triangle ABM. The area of this triangle represents the total thrust due to earth pressure, and any horizontal line from AB to BM measures the intensity, p_E, at that point.

$$p_H = \frac{H\tan\Theta}{b} = \frac{2100}{6(1.732)} = 202 \text{ lb./sq. ft.}$$

Plot this intensity on the line BM. Since the intensity is uniform, the pressure diagram is a parallelogram, as indicated by OSMN.

$$p_V = \frac{w\tan^2\Theta}{2x}(x-a) - \frac{k\tan^2\Theta}{4x}(x^2-a^2)$$

$$p_V = \frac{2400(0.5774)^2}{2x}(x-3) - \frac{350(0.5774)^2}{4x}(x^2-9)$$

$$= 400 - \frac{937.2}{x} - 29.2x$$

The intensity p_V is a variable depending upon x. It is, therefore, necessary to compute a number of values of p_V corresponding to different values of x. The computations can conveniently be arranged in tabular form, as below.

x	$\frac{937.2}{x}$	29.2x	p_V
3	312.4	87.6	0.0
4	234.3	116.8	48.9
5	187.4	146.0	66.6
6	156.2	175.2	68.6
6.93	135.3	202.4	62.3

The maximum value of p_V may be easily obtained by the differential calculus, thus:

$$p_V = 400 - \frac{937.2}{x} - 29.2x$$

$$\frac{dp_V}{dx} = \frac{937.2}{x^2} - 29.2 = 0$$

$$x^2 = \frac{937.2}{29.2};\ x = 5.67$$

$$p_V(\max) = 400 - \frac{937.2}{5.67} - 29.2(5.67) = 69.6 \text{ lb./sq.ft}$$

Add the above values of p_V to p_E and p_H on the pressure diagram and draw a curve through the plotted points. The figure ABOST is the pressure diagram for the total thrust P, which is equal to the area of the figure, and the point of application is in a horizontal line through the center of gravity of the figure. The problem can be considerably simplified if, for p_V, a uniform intensity equal to the maximum value of p_V is substituted, in which case the error is very small and on the safe side. If this substitution is made it is not necessary to compute the various values of p_V but it will be sufficient to find the maximum value, which is 69.6. The figure NST will then become a parallelogram NSS′T′ with a base equal to 69.6.

If g_E, g_H, and g_V are the distances from the base AT to the centers of gravity of p_E, p_H, and p_V respectively,

$$p_E = \tfrac{1}{2}(467)14 = 3269 \text{ lb.} \qquad g_E = \frac{14}{3} = 4.67 \text{ ft.}$$

$$p_H = 202(6.80) = 1375 \text{ lb.} \qquad g_H = \frac{6.80}{2} = 3.40 \text{ ft.}$$

$$p_V = 69.6(6.80) = 474 \text{ lb.} \qquad g_V = \frac{6.80}{2} = 3.40 \text{ ft.}$$

$$P = 3269 + 1375 + 474 = 5118 \text{ lb.}$$

$$g = \frac{3269(4.67) + 1375(3.4) + 474(3.4)}{5118} = 4.21 \text{ ft.}$$

The total thrust is 5118 lb. and its point of application is 4.21 ft. above A.

The case of a vertical wall and a uniformly distributed live load of limited extent, such as a railway or a foundation, is one that occurs much more frequently than the one just

(*Continued on page 132*)

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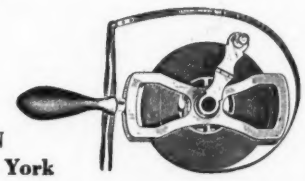

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LATERAL PRESSURES

(*Continued from page 130*)

solved. The thrust can be obtained by formula (5), but it is necessary, in order to compare the result with those of other methods, to reduce all the formulae to the same form.

In one of the methods found in a handbook,[2] the thrust is assumed to be uniformly distributed between the point of intersection of the spread line and the wall and the bottom of the wall, as points G and A, Fig. 5.

The intensity of horizontal pressure against AB due to FD is taken as equal to

$$p_v = Cw$$

in which

$$C = \tan^2 (45° - \tfrac{1}{2}\phi)$$

or

$$p_v = \tan^2(45° - \tfrac{1}{2}\phi)w$$

Referring to formula (5),

$$p_v = \frac{w\tan^2\Theta}{2x}(x_0 - a)$$

whence

$$C = \frac{\tan^2\Theta}{2x}(x_0 - a)$$

Here the value of C, and hence the value of p_v, is proportional to $x_0 - a$, or the length FD. For the maximum value of $x_0 - a$, $x_0 = x_1$, and $a = 0$. If these values are used, and the lateral pressure is assumed to be uniformly distributed from G to A, the error is small and on the safe side, and formula (5) can be reduced to the form

$$p_v = Cw$$

in which

$$C = \frac{x_1\tan^2\Theta}{2x_1} = \frac{\tan^2\Theta}{2}$$

In accordance with assumption (7)

$$\Theta = \tfrac{1}{2}(90° - \phi) = 45° - \tfrac{1}{2}\phi$$

whence

$$C = \tfrac{1}{2}\tan^2(45° - \tfrac{1}{2}\phi)$$

Comparing this value of C with that given by Hool and Johnson, it will be seen that it is just one-half. Thus, the thrust obtained by using formula (5) will not be more than one-half that obtained by using a standard and well-known method.

Another method has been devised by the Design Bureau, Public Service Commission, 1st District, N. Y., and is described by Paaswell.[3] The total thrust is

$$P_v = W\tan(m - \alpha) = W\tan(90° - \Theta - \alpha)$$

in which $W = wb$ is the total effective superimposed load, and P_v is uniformly distributed from the base of the load to the bottom of the wall, or from X to A, Fig. 5, so that

$$p_v = \frac{wb\tan(90° - \Theta - \alpha)}{y_1} = \frac{w\,y_1\tan\Theta\tan(90° - \Theta - \alpha)}{y_1}$$

$$= w\tan\Theta\tan(90° - \Theta - \alpha)$$

whence

$$C = \tan\Theta\tan(90° - \Theta - \alpha)$$

in which α is the angle between the normal to the plane of rupture and the line of action of the force against the plane of rupture (see Fig. 5). Assuming $\alpha = 30°$,

$$C = \tan\Theta\tan(60° - \Theta)$$

But $\Theta = \tfrac{1}{2}(90° - \phi)$; therefore

$$C = \tan(45° - \tfrac{1}{2}\phi)\tan[60° - (45° - \tfrac{1}{2}\phi)]$$

$$= \tan(45° - \tfrac{1}{2}\phi)\tan(15° + \tfrac{1}{2}\phi)$$

In the following table are given values of C obtained by the two methods mentioned as well as by formula (5) for values of ϕ from 24° to 40°. A glance at the table shows that the proposed method gives the lowest values.

ϕ	C		
	Hool & Johnson	Paaswell	Del Bourgo
24	0.421	0.325	0.211
26	0.390	0.321	0.195
28	0.360	0.332	0.180
30	0.333	0.333	0.167
32	0.306	0.332	0.153
34	0.283	0.321	0.141
36	0.252	0.325	0.126
38	0.238	0.329	0.119
40	0.218	0.327	0.109

The above discussion is purely theoretical, no experimental verifications having been made. A series of experiments will no doubt reveal very interesting results, and it is the hope of the writer that this article may suggest to the reader a line of research that may prove profitable.

[2] Hool & Johnson, Concrete Engineers Handbook, 1918, p. 577 and 581.
[3] For a full description of this method and the derivation of formulae, see Paaswell, *Retaining Walls*, pp. 28 and 29.

COLLOIDS

(*Continued from page 115*)

sidered today as a definitely established new branch of chemistry and physics in general. Its importance in our entire life and in practically every branch of industry is becoming more and more evident. This is proved by the interest colloidal research is receiving throughout the world and by the increasing demand for men trained in colloidal science and its applications. The time has come when we are more and more in need of what I have termed "colloidal engineers", who, besides having full training in chemistry and engineering practice, should be equally equipped in regard to the science and technology of colloids.

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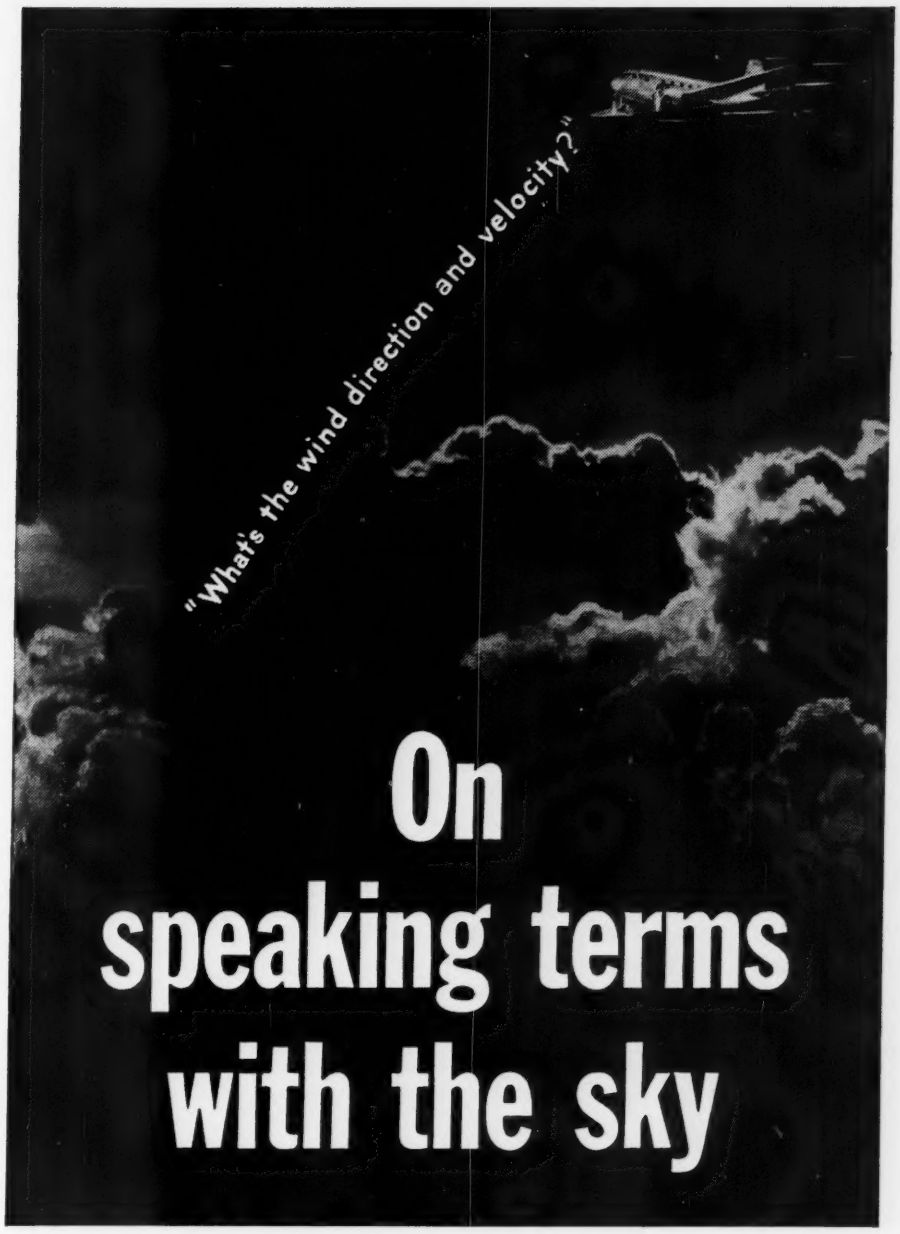

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SCIENCE AND INDU

G-E *Campus News*

PATENTED LILIES

WHEN left to their own devices, regal lilies get themselves all spattered by yellow pollen. It's a messy business—like a man in a white linen suit spilling egg yolk all over his vest. So the florists have to watch these blooms carefully and pluck the pollen-laden anthers before they have a chance to burst.

In the General Electric Research Laboratory, C. N. Moore, Dartmouth, '05, has for years been investigating the biological effects of x-rays. Among other things, he treated 75 regal-lily bulbs with varying amounts of x-rays. Untreated bulbs of the same batch grew up normally. Among the treated bulbs, there were some monstrosities and some apparently normal flowering plants. The results were different the next season. The progeny of two of the bulbs that had received 30-second doses of x-rays produced flowers with nonshedding anthers. Each year the new strain has continued true, and the nonshedding property is considered a fixed characteristic. The Roentgen lily, as it is called, is now established as a variety of regal lily.

AWARD FOR COURAGE

IN the face of a difficult and serious competitive situation, the entire personnel of the Tennessee Electric Power Company, of Chattanooga, under the leadership of its president, proceeded to develop one of the most unique sales programs ever carried out by an American public utility. Every individual in the organization, regardless of position, became a salesman for the company's kilowatt output.

One of the bases of this program was a substantial reduction of rates. The result was a great increase in electric-appliance sales, and a 26-per-cent increase in residential consumption.

The company co-operated in the sale of appliances with dealers, with the TVA, and with the EHFA. Its industrial department has been at least partly responsible for the location of 29 additional industries, employing 1995 workers, in the territory it serves.

For these accomplishments, the Tennessee Electric Power Company received the annual award for 1934 of the Charles A. Coffin Foundation, which was established by General Electric in 1922 in honor of its first president. The award comprises the Charles A. Coffin gold medal, a certificate, and a check for $1000 to be deposited in the treasury of the utility's employee welfare association.

GOOD-BYE, GARBAGE CAN

THE oil furnace has placed the skids under the ash can. And now, a new device developed in a General Electric laboratory promises to do away with the garbage can. This new device, operated by a ¼-horsepower electric motor, grinds the waste food. Grinding knives made of Carboloy—a metal next to diamond in hardness—shred all types of waste food, including bones and other hard substance. The only things it cannot handle are glass and tin cans. Reduced to a fine pulp, this waste is flushed by water into the sewer.

The grinder is simple to install and operate. The entire unit weighs about 75 pounds, and may be installed under any style of sink as a part of the outlet plumbing. The hopper inlet is covered by a perforated cap, flush with the sink bottom. When the hopper is full, all one has to do is turn a handle which projects conveniently from beneath the sink. This closes the hopper and starts the grinder. In the average family, the grinder will operate not more than five minutes a day, and its average cost of operation per month will be about one-half that required for operating an electric clock.

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